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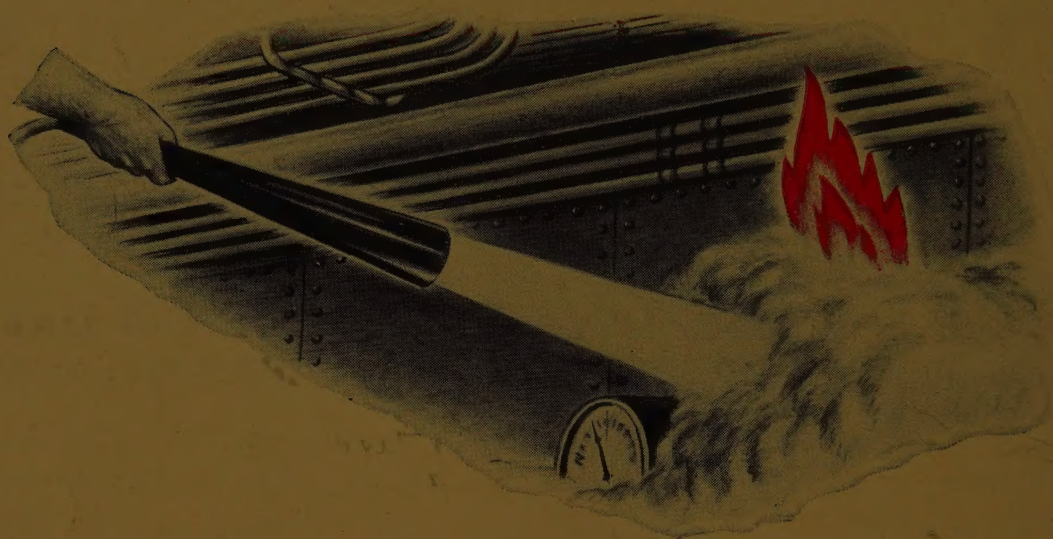


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Plastics

Air Traffic Control

GLEN A. GILBERT

IN ANY DISCUSSION of air traffic control, it is important to keep clear the distinction between *airway* and *airport* traffic control. Airway traffic control extends out along all the airways crossing the country and functions by *advance planning*. Airport traffic control is localized to a small zone around an airport and functions by caring for *immediate* situations. Thus, airway traffic control might be compared to the railroad dispatcher regulating the movement of trains along the routes between terminals, and airport traffic control to the yardmaster regulating the movement of trains into and out of the yards and shunting trains about a terminal. Both have important functions, and the transition from one to the other must be effected smoothly and efficiently. Integration of *airway* and *airport* traffic control forms one service—*air traffic control*.

The primary purpose of air traffic control is the same as surface-vehicle traffic control—protection of life and property by avoidance of collisions. This is accomplished along the airways by airway traffic-control centers and at busy airports by airport traffic-control towers. Providing safety, however, is not the only purpose of air traffic control. Although safety comes first, just as important a purpose from the standpoint of mature air transportation is the expeditious movement of traffic. Air traffic control must be designed to keep traffic flowing evenly and with as little delay as possible. Air traffic control must organize the movement of air traffic so that airports are available for business and space in the airways is not going idle while pilots are waiting to fly.

PILOT REQUIREMENTS FOR AIR TRAFFIC CONTROL

The air traffic rules of the civil air regulations establish two types of flight based on weather conditions. One is flight in accordance with "contact flight rules" and the other is flight in accordance with "instrument flight rules." Flight in accordance with contact flight rules may be described as "clear-weather flying." These rules govern flight in weather conditions where the pilot can navigate by visual contact with the ground and landmarks along the ground, and where the visibility is such that the pilot can see other aircraft soon enough to avoid

Air passenger traffic will increase five times and air cargo 30 times by 1950, predicts this authority in the field of air traffic control. He indicates that further advancement and comprehensive planning are needed if air traffic control is not to hamper the future development of air transportation.

collision. Aircraft flying under contact flight rules need to comply only with general rules of the road and are not subject to ground control, except at busy airports. This control is provided by airport traffic-control towers, 110 of which are today being operated by the

Civil Aeronautics Administration.

The other type of flight—flight in accordance with instrument flight rules, may be described as "bad-weather flying" or "blind flying." These rules govern flight in weather conditions where the aircraft is being flown in or above cloud formations or where the visibility is not sufficient to permit pilots to see other aircraft soon enough to avoid collision. Pilots flying under instrument flight rules are subject to strict ground control. This ground control is exercised in the continental United States by 23 airway traffic-control centers of the Civil Aeronautics Administration, each of which controls an area averaging 1,600 miles of civil airways.

The instrument flight rules require that a pilot, prior to taking off, must submit his flight plan to the appropriate airway traffic-control center and receive approval for the proposed flight. In flight, the pilot must report his time and altitude over radio fixes and must comply with traffic-control instructions issued by the airway traffic-control centers. All classes of aircraft flying the civil airways under instrument flight rules are subject to this control, including airline aircraft, private aircraft, and Army and Navy aircraft.

GROUND AIDS FOR AIR TRAFFIC CONTROL

The radio navigation facilities of the United States have been planned, developed, and established in accordance with the theory that the ordinary work and responsibility of navigating any particular aircraft should be that of the pilot himself. These facilities are constructed and installed so as to provide an elaborate network of routes and markers, continuously operating regardless of the amount of traffic. This network permits a pilot to guide his own aircraft between any two points, much as a motorist with a road map can find his own way easily from city to city.

A system of radio ranges forms the skeleton of the civil airways of the United States so that, insofar as possible, an uninterrupted radio-range-course path is provided for a pilot flying along the airways. In addition to the directional guidance provided by the radio ranges, pilots are able to determine their position along the airways by means of radio "markers."

Essential substance of an address presented before the transportation group of the New York Section of AIEE, in New York, N. Y., January 12, 1944.

Glen A. Gilbert is chief of the air traffic control division, Civil Aeronautics Administration, Department of Commerce, Washington, D. C.

To make possible the control of air traffic, an extensive network of air-ground and point-to-point communication facilities is necessary. The majority of domestic air-ground communication is accomplished by two-way radio telephone. Ground stations are operated by the Civil Aeronautics Administration, military agencies, and commercial airlines, each rendering a specific type of service.

The Civil Aeronautics Administration operates those voice-radio communication facilities which are a part of the navigation facilities. That is, each radio-range station has, in addition to its navigation signals, a voice channel operating on the same frequency. This permits a pilot to receive both navigational guidance and voice communications over one radio receiver.

To connect the various communication facilities with airway traffic-control centers, a total of approximately 35,000 miles of leased telephone lines is provided, serving over 1,600 individual stations. These facilities are used to collect information concerning the movement of aircraft and to send out instructions from the traffic-control centers for relay to pilots by the appropriate radio station.

Each airway traffic-control center is connected to the adjoining center by teletype circuits over which messages

collision between aircraft by establishing vertical separation, time separation, or lateral separation. These three types of separation mean, in effect, that each aircraft is protected from collision with other aircraft by virtue of operating in a reserved constantly moving portion of the air space which is approximately 30 miles long (based on ten minutes flying time at an average of 180 miles per hour) five miles wide (one-half the width of the civil airways) and 1,000 feet high (minimum vertical separation provided pilots when visibility is less than one mile). The traffic clearances issued by the airway traffic-control centers include the points to and from which an aircraft is cleared, approved altitude level at which flight is authorized, holding instructions when necessary, approach instructions, and the time pilot may expect to receive permission to land when congested traffic conditions exist.

An airport traffic-control tower is established at airports where the traffic density is so great that pilots themselves cannot afford separation when landing, taking off, and taxiing. Control towers are so situated as to provide controlling personnel with an unobstructed view of the landing area and all approaches. Airport traffic is controlled by means of radio and light signals so as to provide

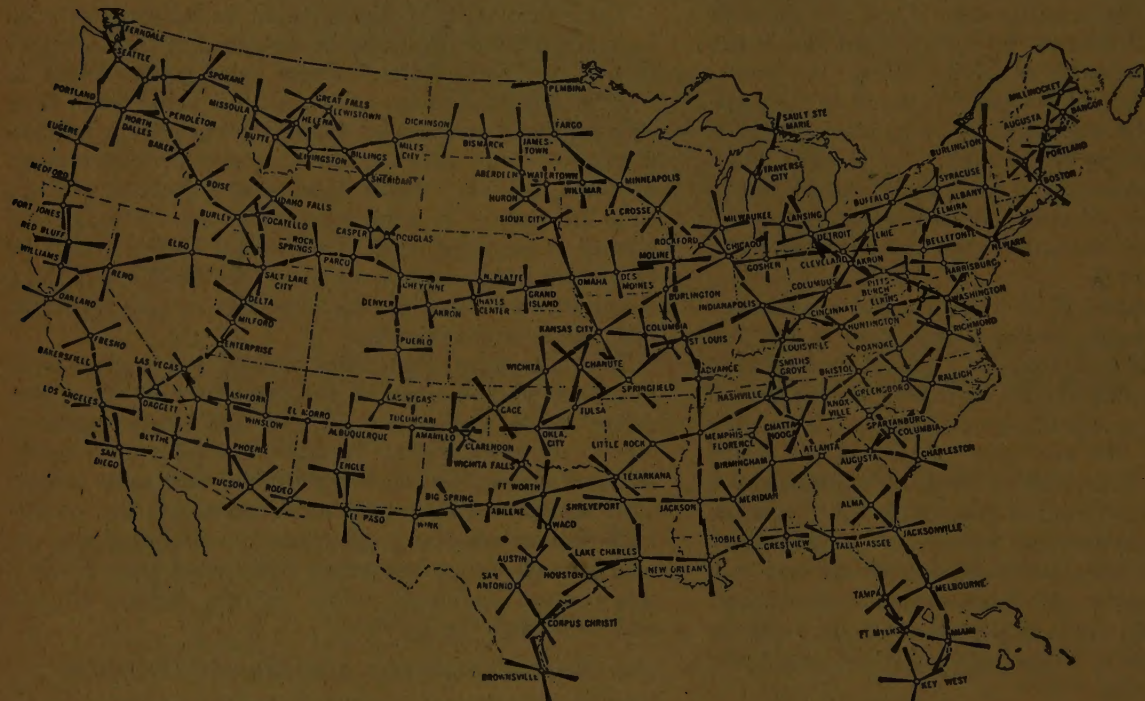


Figure 1. Radio-range system of the United States
312 radio-range stations
183 fan-type markers

are transmitted concerning the flow of traffic from the area under one center to the area under another center. At present over 11,000 miles of these circuits are in operation, and during 1944 it is expected that the Civil Aeronautics Administration will extend this service to a total of approximately 25,000 miles in order to handle the increasing air traffic loads.

AIR TRAFFIC SEPARATION

As pointed out earlier, airway traffic control is provided by airway traffic-control centers and airport traffic control by airport traffic-control towers. An airway traffic-control center issues traffic clearances and control instructions to aircraft flying under instrument flight rules within the limits of the civil airways in its control area. It prevents

adequate separation between aircraft while on and in the vicinity of the airport.

PREWAR EUROPEAN SYSTEM OF AIR TRAFFIC CONTROL

So far, only the United States system of air traffic control has been discussed. It will be of interest to consider briefly systems of control outside the continental United States. The countries of prewar Europe, in contrast to this country, had no established airways. The basic system of air navigation was that of radio direction finding. This system required that ground stations take bearings on the aircraft at frequent intervals and forward them to the pilot in order that he might follow the desired course. Practically all of the air-ground communication was

accomplished by radio telegraphy, using international Q signals.

Shortly before the outbreak of the war in 1939, the English system of air traffic control became somewhat similar to that of the United States in that "control areas" and "inner controlled zones" were established in some sections. Aircraft within the control area were required to report before entering a cloud formation or conditions of bad visibility; to give position, height, and track; and subsequently to report any alteration. Aircraft were not allowed to enter the inner controlled zone nor to land without the permission of the control officer in the control tower.

ENGLISH WARTIME SYSTEM OF AIR TRAFFIC CONTROL

In describing the English wartime system of air traffic control, obviously, no information can be revealed which has not already been released or is a matter of common knowledge. Basically, the flying-control organization of the Royal Air Force is responsible for control and safety of all air traffic from the time of departure from the hangar or dispersal point until the aircraft has returned and is again at a hangar or dispersal point. The RAF flying control provides two methods of control over aircraft—local control, comparable to United States airport traffic control, and sector control, comparable to United States airway traffic control. One of the main purposes of the Royal Air Force flying-control organization is the provision of navigational guidance for aircraft to and from military objectives and the dispersal of arriving aircraft to airfields where the most favorable conditions exist. Information available indicates that air traffic control as known in this country—that is, the issuance of instructions for the prevention of collisions between aircraft—is exercised only on and in the vicinity of landing areas and then, as a general rule, mainly under contact weather conditions.

SYSTEMS OF AIR TRAFFIC CONTROL IN WESTERN HEMISPHERE

The systems of air traffic control in the Western Hemisphere vary from little or no control in South and Central America to the highly developed control system north of the United States-Mexican boundary. In general, no control is provided except by infrequent airport traffic-control towers, in Mexico, Central America, and South America, whereas the United States, Canada, and Alaska follow the system described for the United States.

LIMITATIONS OF PRESENT AIR TRAFFIC-CONTROL SYSTEM

Let us next consider limitations of the present United States system of air traffic control. At first glance, it might be thought that *safety* is the sole standard which would define these limitations. Safety, within the inherent characteristics of the aircraft and subject to capabilities of the pilot, can always be provided. The tool of last resort available to air traffic control to achieve this result is the restriction of aircraft movements. Carried to absurdity, this means that, upon warning of the approach of bad visibility and lowering ceilings, all aircraft could be grounded, and but a single plane could be permitted to move in any one section of the country. No collisions could occur, and safety of the highest possible order would be provided insofar as the air traffic-control system is concerned.

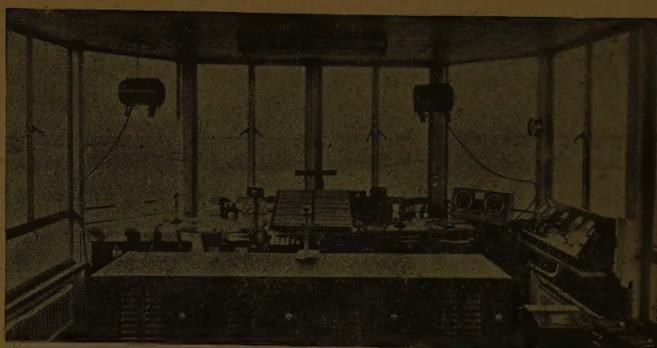


Figure 2. Airport traffic-control tower



Figure 3. Airway traffic-control center

Although safety must be provided at all times, the insurance of safety cannot be the sole standard for judging the performance of air traffic control. The standard of judgment must be based upon the *efficiency* with which traffic is safely guided.

Assuming that air traffic control does not prevent any flight from taking to the air or remaining in it, there are several possible standards for judging its efficiency. In ascending order of difficulty in achievement, these are:

1. Safe landing of all aircraft at any available point at any time.
2. Safe landing of all aircraft at intended destination at any time.
3. Safe landing of all aircraft at intended destination in scheduled or normal flight time, within reasonable limits.
4. Safe landing of all aircraft at intended destination exactly on schedule or in normal flight time.

The present standard of efficiency of air traffic control is somewhere between standard 1 and standard 2. During the next few years the standard of control efficiency must rise to number 3. The highest standard, number 4—safe landing of all aircraft at intended destination exactly on schedule, or in normal flight time—must be closely approached before air transportation can become fully mature. It can be expected that this standard will be demanded by the traveling public and the shippers in the not too distant future. The air-traffic-control system must be capable of meeting the desired standards, or air traffic control may become the one factor which will limit the utilization of air transportation in the future.

IMPROVEMENTS PLANNED BY THE UNITED STATES

A program of improvements in the United States system of air traffic control has been planned by the Civil Aero-

navies Administration and is being activated as rapidly as circumstances permit. Included is an improved navigation system using very high-frequency radio ranges and the provision of more adequate air-ground and point-to-point communication facilities, the establishment of an automatic system for the handling of flight data required for air traffic control, and improved control procedures based on the use of the new facilities. This program of improvements is expected to increase greatly the capacity of the present air-traffic-control system by making possible more approaches during instrument weather conditions and reducing separation between aircraft along the airways.

At airports, successive landings under instrument weather conditions should be possible at three-minute intervals. Thus, the capacity of a properly facilitated airport will be approximately 20 arrivals and 20 departures or approximately 40 aircraft movements per hour. This compares very favorably with the present situation whereby airports today can handle only approximately ten aircraft movements per hour during instrument weather conditions.

Along the airways substantial reduction in time separation should be possible between aircraft flying at the same altitude. Instead of the 15-minute separation between aircraft existing on some airways today due to insufficient fixes, and a minimum of ten-minute separation on all other airways, it is expected that the improvements planned will make possible a reduction in this separation to perhaps five minutes.

This means that the plans of the Civil Aeronautics Administration which are now ready and which can be placed in effect in the immediate future will result in an increase in capacity of the United States air-traffic-control system to at least four times its present capacity.

AIR-TRAFFIC DEVELOPMENT

Will this expansion be sufficient to provide for future needs? Many estimates have been made recently as to

the amount of air traffic that will develop after the war. A careful analysis of these estimates and expectations indicates several assumptions which have been generally accepted. These are:

1. Scheduled air passenger traffic by 1950 will increase to approximately 10,000,000,000 passenger-miles, or five times the present air passenger traffic.
2. Air cargo by 1950 will amount to at least 600,000,000 ton-miles of freight, express, and mail moved by air annually, or 30 times that being transported in commercial air carriers today.
3. A total of approximately 500,000 aircraft will be in service in 1950 as compared to approximately 30,000 before the war.

Based on the foregoing, it appears logical to conclude that increases in air traffic by 1950 over that existing in 1941 will be approximately 14 times for air-carrier aircraft, 18 times for private aircraft, and 10 times for military aircraft. If these expectations become a reality, it is obvious that the improvements now planned will be merely stopgaps. Further advancement in the field of air traffic control will be required in the years immediately following cessation of hostilities.

FUTURE PLANNING

Much has been said about the possibilities of wartime developments revolutionizing or at least radically changing the present system of air traffic control. The war without question has accelerated many technical developments. Special progress has been made in the field of electronics. However, application of the various principles and techniques developed of necessity has been directed entirely toward wartime needs.

It appears, therefore, that very few, if any, wartime technical developments will be immediately applicable without change to meet peacetime needs. The end of the war will bring improved technical principles and techniques, but their application to peacetime requirements will have to be worked out. Moreover, it would seem that such wartime technical developments as will be

available and gradually adopted for peacetime aviation before—say—1950 will be only supplemental and assisting with respect to the present air-traffic-control system.

As an example in support of this line of reasoning, it might be pointed out that there is a widespread opinion that radar devices will greatly change air traffic control in the immediate postwar

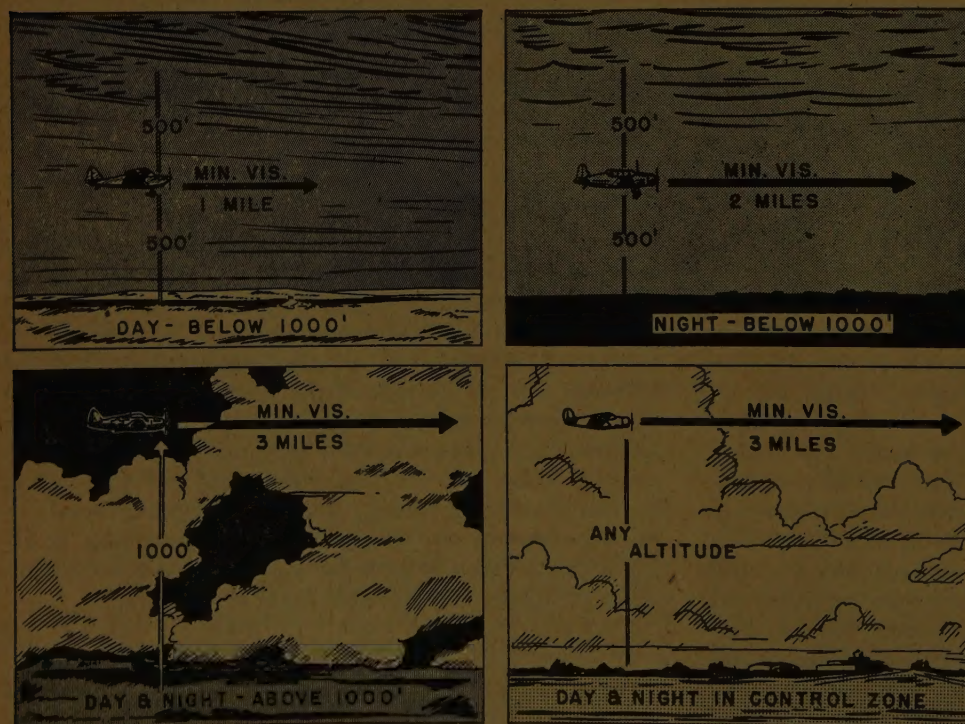
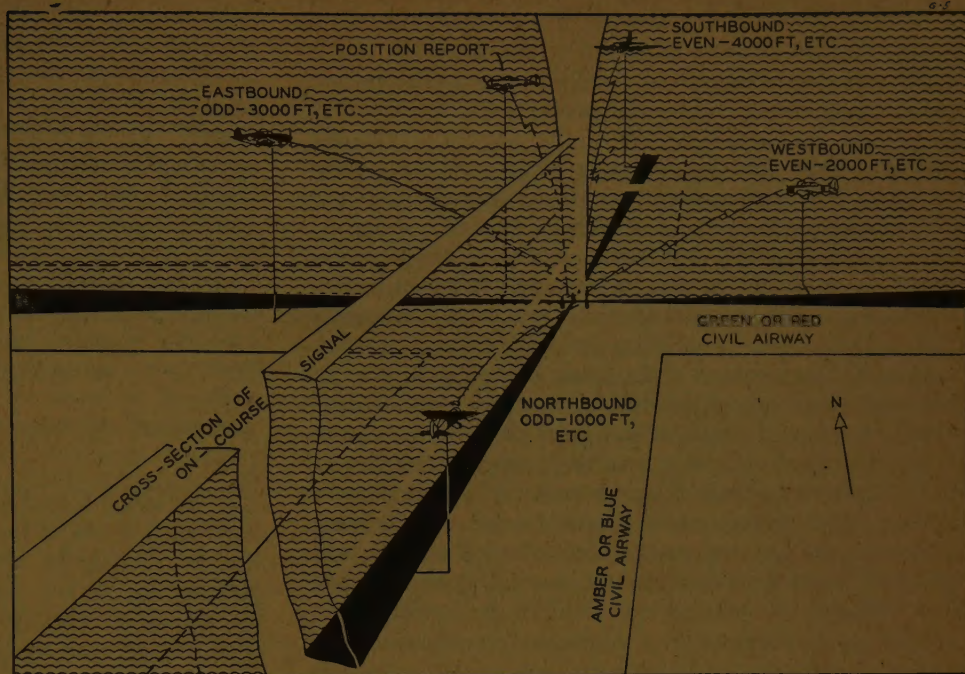


Figure 4. Contact-flight-rule weather minimums

Weather limitations for flight in accordance with contact-flight rules, illustrating visibility and distance from cloud minimums

Figure 5. Flying the civil airways

When flying the civil airways by use of instruments, pilots are required to follow instructions issued by airway traffic-control centers and airport traffic-control towers. Aircraft are assigned specific altitudes and must report time and altitude at reporting fixes



period. An analysis of the principle of radar indicates that it has its main advantage in detecting the presence of objects which will not "cooperate," such as enemy airplanes and ships during wartime. To obtain such detection it is necessary to provide complicated apparatus involving high cost, substantial weight, and special technique for operation.

In the control of peacetime aircraft, however, the situation is entirely the reverse in that all aircraft *will* co-operate. In other words, devices can be placed on board peacetime aircraft which will *reveal* their presence. Thus, it becomes possible to apply a different technique for the detection of aircraft for air-traffic-control purposes in peacetime which will involve less complex apparatus, less cost, less weight, and simpler operation. Certainly some of the improved electronic techniques developed during wartime will be used for air traffic control, but application will be for peacetime requirements, meeting entirely different specifications from those existing under wartime conditions.

INFLUENCE OF WEATHER ON FLYING

In the postwar period and up to at least 1950, it is believed that weather will continue to be a factor affecting flying. Private pilots will refrain from flying during low cloud and restricted visibility conditions in the same way that the average automobile driver avoids using his car during poor driving conditions. There probably will be an increasing number of private pilots who will be qualified to fly in weather conditions requiring instrument flight as a result of wartime pilot-training programs. By and large, however, it is expected that the great majority of private pilots will continue to be "fair-weather" fliers.

Commercial air carriers can be expected to constitute the bulk of poor-weather flying after the war in the same way as they did before the war. Scheduled air-carrier service is economically successful only if conducted regularly. Hence, this type of service must operate under practically all weather conditions. Some military flying involving the larger types of aircraft probably will be accomplished in a manner comparable to the scheduled air carriers. However, it is expected that the majority of postwar military flying will be done only during the more favorable weather conditions. Air traffic control, therefore, will continue to have two types of flying to contend with—good-weather or "contact" flying and poor-weather or "instrument" flying.

FUTURE AIRCRAFT EQUIPMENT FOR AIR TRAFFIC CONTROL

In attempting to eliminate or reduce all limitations of air traffic control so as to increase the capacity and raise the efficiency of the system, several devices for installation in aircraft appear to provide possible solutions. These devices will be identified as a "collision-warning device," an "automatic-position reporter," and a "traffic-clearance indicator." The latter two devices ultimately may be combined to provide a "block signal system."

The ultimate solution for the control of the large number of aircraft anticipated in the future will require that some means be provided which will permit the shifting of a substantial amount of responsibility for the avoidance of collision from ground agencies to the individual pilots of aircraft. In other words, each pilot flying in instrument weather conditions should be able to avoid collision with other aircraft by directly observing indications of the position of the other aircraft. The means to accomplish this probably will be in the form of a "collision-warning device."

Development of one such device, identified as a "vertical-separation indicator," was commenced some time prior to the war by the Civil Aeronautics Administration. This device will permit a pilot, by reference to an instrument upon the aircraft instrument panel, to determine at a glance the vertical separation between his aircraft and other aircraft within a fixed radius and will also indicate roughly the horizontal distance between his and the other aircraft. The pilot thus will be enabled to maintain a specified minimum amount of vertical separation between his aircraft and other aircraft within a certain radius during climb, level flight, and descent.

A somewhat different device might be provided as a "horizontal-separation indicator." This instrument would be a screen on which various size dots would indicate the relative position of other aircraft located within an area ahead of the aircraft concerned, and within at least 45 degrees above and below as well as to the right and left. The size of each dot would represent the approximate

distance to the indicated aircraft and the location of the dot the angular position of the other aircraft.

The development of an automatic aircraft-position reporter would contribute materially to the reduction of one of the major limitations of the present air-traffic-control system—the use of voice as a communication medium. This device would permit an aircraft to actuate a reporting mechanism as it passes each fix along the airways in much the same way as a train trips certain signals as it passes predetermined points on its route. This plan, briefly, would involve the use of a vertical-pattern transmitter at each fix, a receiver in each aircraft to indicate the entrance of the plane into this pattern, an aircraft transmitter continuously set by a controlling altimeter and put into operation under the control of the fix pattern receiver, and a receiver at the fix capable of receiving the automatic report signals and relaying them onward to the airway traffic-control center. At the control center the position reports would be fed directly into automatic posting equipment and would appear in proper form and position before the controlling personnel.

With the establishment of automatic transmission and posting of aircraft-position reports and provision for the automatic transmission of traffic-control instructions from ground personnel to pilots, voice as a communication medium could be eliminated entirely in the control of air traffic. Such a plan involves the storage of traffic-clearance data on mechanized flight-progress boards in airway traffic-control centers and the automatic transmission of these data by radio at appropriate times to actuate a device in the aircraft which might be called a "traffic-clearance indicator."

As visualized, the circumference of the traffic-clearance indicator would be taken up by a series of lamps, one for each flight level. As the plane proceeds at an altitude for which clearance has already been received, the lamp for that level remains lighted. When a clearance to another altitude is received, the lamp for that altitude starts to flash, and the lamp in the center, over the word "change," lights to attract the pilot's attention to the fact that new instructions have been received. This light is extinguished by the pilot when he pushes the "acknowledge" button, causing at the same time the transmission of his aircraft identification and the clearance as it appears on his instrument. This acknowledgment is automatically compared at the control center with the posted clearance, and a disagreement warning appears before controlling personnel if an error is apparent.

The indicators shown in the center of the dial include "go," "hold," "change," and "taxiland." The "taxiland" light is used for airport traffic control when the aircraft is to move on the ground or to authorize a landing. "Go" authorizes a take-off or forward progress at the indicated altitude. "Hold" calls for remaining stationary while on the airport and for maintaining the indicated altitude at the next fix while en route.

It should be understood that transmissions will be made and a pilot's indicator changed only when the pilot must make a change in the procedure he has been following. In many cases only a brief transmission upon departure will be required, plus one or more in connection with landing at destination.

In the much more distant future it may be found necessary to combine the traffic-clearance indicator and the automatic aircraft-position reporter into an automatic

"block-signal system" of a type similar to that used by the railroads. This system, as visualized at this time, would consist of marker transmitters producing a screen across the airways at block-signal "fixes" 10 to 15 miles apart. An aircraft proceeding along an airway so equipped would set up a "hold" signal for succeeding aircraft at the same level which would not be canceled until the preceding aircraft had climbed or descended to the next level or had passed the next block-signal fix along the route. Thus, the block-signal system would provide a warning to prevent two aircraft from being in the same "block"—the air space between two adjacent fixes—at the same altitude.

FUTURE GROUND FACILITIES FOR AIR TRAFFIC CONTROL

In planning for additional ground facilities required to control air traffic of the future, the nature of such facilities will be dependent chiefly upon the accepted aircraft equipment. If the automatic air-traffic-control devices just described are adopted, then corresponding ground facilities also must be provided.

It has been estimated that approximately 850 air stations will be required within the next few years to provide an adequate scheduled air-carrier traffic pattern. This is over three times the present number of scheduled air-carrier stops. Such a service pattern undoubtedly would require that air-traffic-control protection be afforded over all air space within the continental United States. It is not believed that the extension of air traffic control to include all air space will mean the discontinuance of civil airways. Rather, it is expected that civil airways will be continued as channels where a continuous heavy flow of traffic ordinarily exists. Flight outside of these channels will follow individual routes but, nevertheless, will be afforded air-traffic-control protection to the same extent as is provided on the civil airways.

Basically, it is expected that the radio ranges, or comparable directional facilities, will delineate the civil-airways system. Flight off the civil airways probably will be accomplished chiefly by use of automatic direction-finding facilities. With the establishment of automatic air-traffic-control devices in aircraft and with the provision of corresponding ground facilities, there appears to be but one remaining need of air traffic control which will require additional ground facilities. This is the constant portrayal of actual positions of aircraft to controlling personnel.

By the installation of "scanning screens" in airport traffic-control towers, it appears that this requirement can be met. One screen would portray the positions of aircraft in a horizontal plane within perhaps 25 miles of the airport. The aircraft positions would be indicated by a spot of light which would be moving constantly as the aircraft positions change. Another screen would show the relationship of aircraft in a vertical plane along the path followed by aircraft when approaching the airport under instrument weather conditions. A dot appearing on this screen would indicate the altitude of the aircraft and its position in the holding flight path.

FUTURE AIR-TRAFFIC-CONTROL PROCEDURES

It would be highly desirable if the automatic air-traffic-control equipment for aircraft could be light enough and cheap enough so that all aircraft flying under

instrument flight rules would be equipped with these devices. However, it is expected that, at least for a long time, only the larger aircraft will be so equipped. The most optimistic estimate would place not more than 50 per cent of the aircraft flying in instrument weather by 1950 in the category of those having full automatic air-traffic-control equipment. This means that the air-traffic-control system would have to continue to be capable of controlling a substantial amount of air traffic involving aircraft having only the minimum air-traffic-control equipment such as is required at the present time.

However, the automatic devices for aircraft and the ground aids for air traffic control previously described point to the possibility of obtaining the ultimate objective of permitting the flow of air traffic under instrument weather conditions in the same volume and with the same frequency as is possible under contact weather conditions. This means that, at an airport properly designed and adequately served by navigational and air-traffic-control facilities, landings under instrument weather conditions would be possible at 50-second intervals, or approximately 70 landings per hour per runway in use. Thus, future planning seems to indicate that it will be possible for the air-traffic-control system within the United States to reach the level of safety and efficiency which ultimately will be required by mature air transportation.

INTERNATIONAL ASPECTS OF AIR TRAFFIC CONTROL

Most expert opinion anticipates that postwar air transportation will develop internationally in substantial proportions. Extensive international air commerce in the postwar era may be an important factor in cementing all of the nations of the world more closely together. As air transportation becomes global in scope, it is increasingly apparent that worldwide standards for the control of air traffic ultimately must be established if international air commerce is to develop to the fullest possible extent. An airplane flying from Moscow to Chicago, for example,

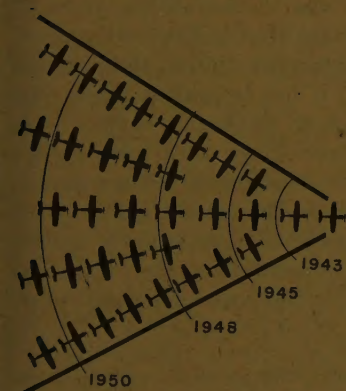


Figure 6. Capacity of air traffic-control system

Each plane indicates four instrument approaches per airport per hour. In 1943 it was possible to handle four instrument approaches per airport per hour. With improved facilities it is planned to accommodate 12 instrument approaches per airport per hour in 1945, 30 in 1948, and 60 in 1950

would pass over areas under the control of at least seven different countries. Obviously, if each country had different systems of air navigation, different flying regulations, and different systems of air traffic control, an extremely difficult if not impossible situation would result.

It is believed, therefore, that one of the most important phases of postwar planning for aviation is the planning of worldwide standards for air traffic control. Such planning should include the formulation of navigation standards, communications standards, aircraft-equipment standards, standards for flight rules and for control procedures.

CONCLUSION

The present basic system of air traffic control in the United States is expected to continue without radical change in the foreseeable future. Improvements now planned will help, but further advancements in air traffic control must be made in the next few years to meet the expected demands of postwar flying.

Military technical developments undoubtedly will become available for air-traffic-control purposes, but application will be to peacetime specifications meeting different requirements from those existing during wartime. Automatic air-traffic-control devices must be perfected which will make it possible for pilots to exercise a substantial amount of traffic separation on their own responsibility. These devices also should eventually make possible the elimination of voice as a communication medium in the control of air traffic. Comprehensive planning must be accomplished so that air traffic control, both domestically and internationally, will not become a bottleneck in the future development of air transportation.

Welding-Electrode Refrigeration

That electrode life can be prolonged, tip pickup retarded, and spot-welding speed increased by electrode refrigeration under good welding conditions was disclosed by recent investigations into the effects of coolant temperatures on spot-welding electrode performance. The project was directed by W. F. Hess (M '41) associate professor of metallurgical engineering and head of the welding laboratory of Rensselaer Polytechnic Institute, Troy, N. Y., the project was sponsored by the Welding Research Council of The Engineering Foundation.

A comparison of the performance of the conventional bored-cylinder electrode and a capped electrode manufactured by Frostrade Products, Detroit, Mich., revealed that water-cooled conventional electrodes lasted an average of 30 spots between tip cleanings whereas the refrigerated capped electrodes produced more than 2,200 acceptable spot welds between cleanings. Doctor Hess reported obtaining better results from the Frostrade electrodes cooled with tap water than from the conventional electrodes cooled by five times the amount of tap water held at the same temperature as that which circulated through the capped electrodes. The tests also showed that the contact face of the capped electrode is affected less than that of the standard electrode by changes in the temperature of the coolant medium because of the efficiency of heat transfer to the refrigerant possessed by the capped electrode.

However, Doctor Hess warned that refrigeration is not a cure-all for the many troubles encountered in spot welding. Neither can the refrigeration correct for faulty practices which sometimes obscure the benefits of a better cooling of the electrodes, according to the report. Alclad 24ST sheet, 0.040-inch thick, was the material used for the welding tests and the temperature of the refrigerant in the capped electrode was held at 0 degrees Fahrenheit. The test conditions consisted of welding as continuously as possible until the electrodes showed evidence of having been in use too long.

Recent Developments in Light Sources

PRESTON S. MILLAR
MEMBER AIEE

LIGHT is usually produced through the process of either incandescence (which for this general discussion may be taken to include combustion) or luminescence. Sources brought to a glowing temperature of incandescence are usually accompanied by infrared or heat radiation and very little ultraviolet radiation. Those that produce light through the process generally characterized as luminescence are electronic devices that may produce a good deal of ultraviolet as well as infrared radiation. Generally speaking, incandescent sources provide continuous spectra, whereas luminescent sources provide line or band spectra. Indications of several responses to radiation in the ultraviolet, visible, and infrared regions are set forth in Figure 1.

Radiation between wave lengths approximately 3,800 and 7,600 angstroms stimulates the human eye to vision. This narrow band of about one octave, out of about 80 octaves of the electromagnetic spectrum, is adjoined immediately by shorter wave lengths in the ultraviolet region that are applied in producing fluorescence and for photochemical and germicidal purposes. It is adjoined immediately by longer wave-length radiation that is utilized for drying and heat therapy.

It perhaps will not be out of place to recall further that the response of the human eye to radiation within the visible spectrum varies greatly for radiation of different wave lengths, attaining to a maximum value near the middle of the visible spectrum at about 5,550 angstroms with a shift of this maximum toward shorter wave lengths as intensity is decreased. The relative luminosity curve of normal human vision has been established by the International Commission on Illumination as in Figure 2.¹ These are the accepted data for the visual response of the human eye to radiant energy of various wave lengths.

Electric lamps are available in wide variety, having different qualities that fit them for application under different circumstances for several distinctive purposes. In some respects they may be likened to the instruments of an orchestra. Each has its place. All fulfill some useful purpose. The range of sounds of the orchestral instruments from the deepest "umph" of the contrabass tuba to the shrillest note of the piccolo is of the order of seven octaves. The composer calls upon them individually and in any combinations to produce desired effects. Electric lamps produce radiation of frequencies covering a range of like extent from the longest-wave infrared of glowing bodies to the shortest-wave ultraviolet radiation. The engineer may draw upon the resources

Recent advances in the field of illumination before the war and the probable postwar developments and applications furnish the subject of this article. Arc, tungsten-filament incandescent, infrared, mercury-vapor, sodium-vapor, and fluorescent lamps are discussed in detail.

of any one or of, a combination of types of radiators, according to the purposes to be served.

Electric lamps that meet more or less successfully the requirements for radiation throughout the entire optical spectrum are commercially available. Indeed, many of

these requirements may be served by alternative devices that are competitive and that have different characteristics, thus affording the engineer a choice of methods. The only lack in the materials of illumination is war-begotten and temporary. For practically all forms of electric lamps have gone to war. The more essential types are still being produced, but the number of types has been halved. Development of light sources is confined to military applications. New developments for civilian use wait upon victory. Any account of advances in light sources at this time must be lacking in news value. The principal American lamp manufacturers perform exceedingly well the task of supplying to engineers informative material concerning their several products. Their technical and commercial publications are comprehensive and informative, and they have responded helpfully to every request of the author for material for this article.

Arc Lamps

This oldest of electric illuminants has an interesting and honorable record of service in the earlier years of electric street lighting—a service that it has relinquished for the most part to a younger generation of illuminants. In other directions, however, it has become a lively and useful device. As a high-power projection source it is particularly valuable. In producing ultraviolet radiation it is also important. The principal American manufacturer of arc carbons indicates that, as is the case with most electric illuminants, the electric arc lamp is undergoing dynamic development, diverted for the present to war purposes, but promising for the postwar period. For instance:

For searchlight work, experimental high-intensity carbons have doubled present-day performance, attaining to a brilliance of 2,000 candles per square millimeter, or better.

Improvements in carbons, in applicable optics, and in methods of operation promise delivery of three times as much light to motion-picture screens as is attained commercially today.

High-purity spectroscopic carbons are finding large use for war purposes in rapid checking of critical alloys for impurities. This method of analysis is used extensively in the aluminum, brass, and copper industries and is understood to be coming into extensive use in the steel industry.

The carbon arc in latest development gives a close approach to quality of sunlight in the near ultraviolet region that is most effective in photochemical reactions.² These arcs are used largely in ac-

Essential substance of an address presented under the sponsorship of the AIEE committee on production and application of light at the conference on lighting, AIEE winter technical meeting, New York, N. Y., January 26, 1944.

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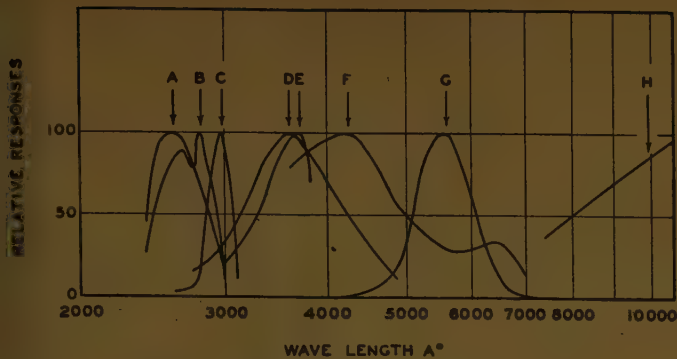


Figure 1. Some effects of radiant energy

- | | |
|------------------------|------------------------|
| A—Bactericidal | E—Fluorescence—paints |
| B—Vitamin D in sterols | F—Panchromatic film |
| C—Tanning | G—Vision |
| D—Photoprinting | H—Penetration of cheek |

celerated weathering or fading tests in the protective coating, rubber, and textile industries. They are used also for the irradiation of milk, tobacco, and pharmaceutical products.

Tungsten-Filament Incandescent Lamps

In variety, range of sizes, simplicity, readiness of application, and wide acceptability, incandescent lamps are of very great importance in electrical service. American achievements in production and use of such lamps are pre-eminent.³ The relatively low American rates for electric energy and the relatively low prices for American lamps have made possible notable advances in electric-lighting practice. Figure 3 shows the cost of producing a stated amount of light with tungsten-filament lamps for the year 1943 compared with the cost for the year 1921.⁴ The entire rectangle represents the cost of light in 1921. The rectangle designated A represents corresponding 1943 cost. The reduction has been accomplished by advance in three elements of cost. Improved lamp efficiency (B) and lowered rates for energy (C) made the major contributions. Lowered lamp prices added considerably to the accomplishment. The combined result is that light which would have cost \$10.21 in 1921, cost \$2.86 in 1943.

TYPES AND SIZES

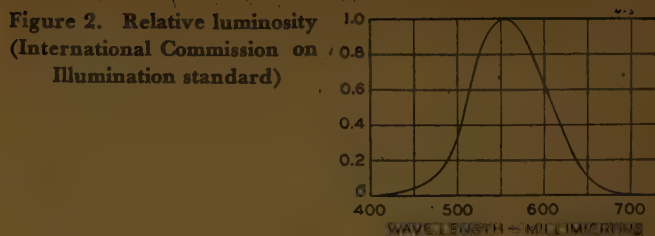
It is said that previous to the war there were some 9,000 distinctive types or sizes of lamps, including many for highly restricted applications. Approximately half of these types have been eliminated in the process of war-time conservation. Among the commonly used types so eliminated have been the 50- and 75-watt lamps and certain decorative types of lamps.

On the other hand, it is said that approximately 200 new types and sizes of incandescent lamps have been required for specialized war service. Lamp manufacturers have made a real contribution to the war effort through

1. The development of these new types of lamps as needed.*
2. Maintenance in high degree of the quality of their products despite deprivation of critical materials that to some of us might have seemed essential to the production of satisfactory-quality lamps.

In Figure 4 a cluster of charts shows for the record the approximate quantities of certain types of incandescent

* It is stated that a modern bomber plane uses about 200 electric lamps of various shapes and sizes. A battleship requires almost 30,000 lamps. A General Sherman tank (M-4) uses 27 lamps, and a full armored division requires about 60,000 lamps.



lamps sold during the last prewar year, chosen for this purpose as being more representative than the subsequent wartime years. Not included in these charts, but of importance, were 48,000,000 radio-panel lamps and 256,000,000 Christmas-tree lamps.

The smallest lamp made is the so-called "grain-of-wheat" lamp, employed in surgical work. This consumes 0.17 watt and produces about one third of a lumen. The lamp itself is but 0.079 inch in diameter and 0.343 inch long. Manufacturers say that if sold by weight this lamp would cost about \$7,500 a pound, because it weighs only 0.06 gram.

The largest incandescent lamp made is of 50,000 watts. It has a bulb 20 inches in diameter and weighs about 35 pounds. It produces 1,600,000 lumens or about the same amount of light as 1,000 100-watt lamps. The filament alone weighs about 1.6 pounds. One has the impression that this lamp was constructed somewhat as a stunt before the war when materials were not limited. It certainly has not entered much into practical use.

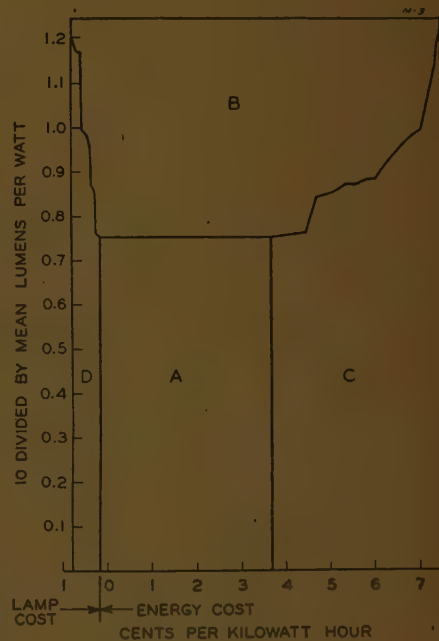
The range of application of the incandescent lamp is certainly remarkable. This will be appreciated when compared, for example, with the present range of other types of light sources.

RECENT DEVELOPMENTS

"Recent" in this connection means recently before the war. Among recent developments has been the extension of the all-glass sealed-beam lamps, devised originally for automotive head-lamp purposes in the 6- to 8-volt range, to make them available for 12- to 16-volt range for trucks

Figure 3. Lamp and energy cost of light from 60-watt specification-quality incandescent lamps (dollars per million lumen-hours)

A—Cost of light, 1943.....	\$ 2.86
<i>Reductions since 1921</i>	
B—Through lamp efficiency increase...	3.39
C—Through lowered rates for energy...	3.33
D—Through lowered lamp prices.....	.63
A+B+C+D=	
cost in 1921.....	\$10.21



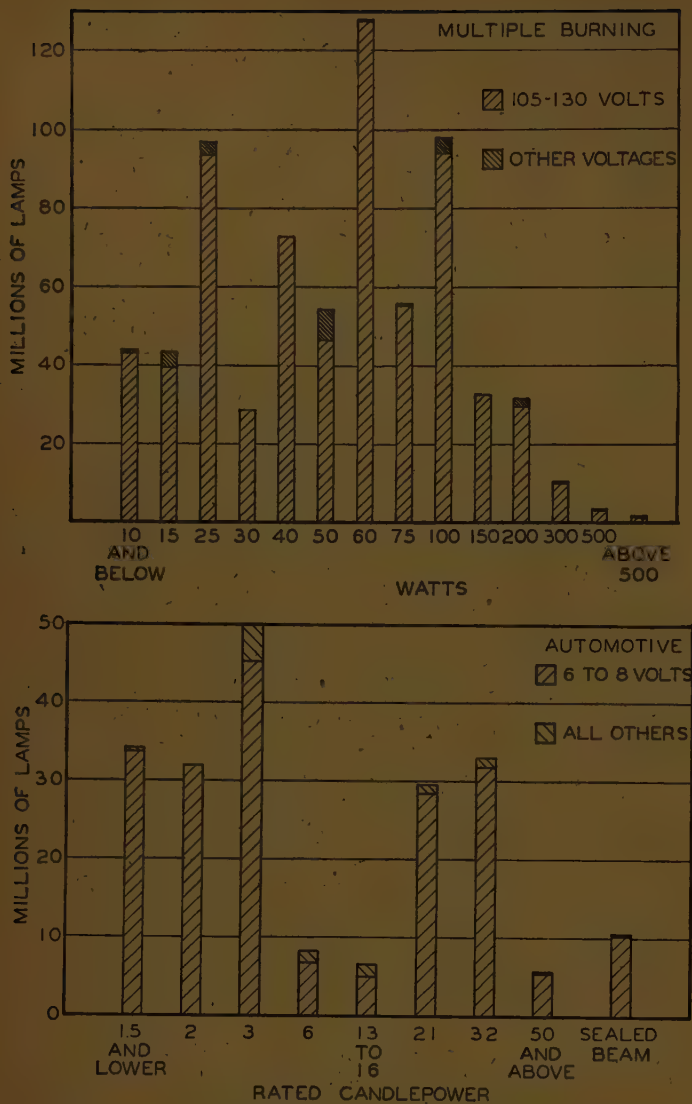


Figure 4. Quantities of certain types of tungsten-filament incandescent lamps produced in the United States in 1941

and 12- to 24-volt range for aviation work, in which sizes have gone up to as much as 600 watts. Smaller sealed-beam construction lamps were made available for aviation fields, spotlights, flashing signal lamps, and so forth.

Concentrated high-intensity illumination for indoor use and with hard pressed-glass bulb for outdoor use is available in reflector-embodied lamps.

EFFICIENCY

Incandescent lamps are rated in terms of lumens per total watt input. An analysis of the energy input to a 60-watt tungsten-filament lamp of modern construction is shown in Table I.⁵

There has been a steady advance in the efficiency of light output of incandescent lamps in recent years. The 7.8-lumen-per-watt 60-watt lamp first introduced had become a 13.9-lumen-per-watt lamp. The range of efficiencies of modern tungsten-filament lamps is from 4.5 lumens per watt in the case of three-watt 120-volt lamps to about 36 lumens per watt in the case of the short-life photoflood lamps. Among lamps generally employed for illumination purposes the range is approximately 9 to 21 lumens per watt. It is probably a fair estimate that incandescent electric lighting is accom-

plished with a light-production efficiency of about 13 lumens per watt. This is comparable to about 40 lumens per watt for fluorescent lamps. Maximum efficiency of solar radiation has been estimated at approximately 86 lumens per watt, corresponding to black-body radiation at 6,500 degrees Kelvin.⁶

PERFORMANCE

The characteristic performance of specification-quality lamps* of the usual residence-lighting types is shown in Figure 5. The 60-watt lamp, the most widely used size, declines about ten per cent in lumens to the end of its 1,000-hour life and about seven per cent in efficiency. Rated lives of other lamps range from 2 hours for photoflood lamps to 3,000 hours in the case of some types in which replacement is difficult. The life of incandescent lamps, of course, depends upon the filament temperature, varying inversely as about the seventh power of the lumens per watt. For lamps entering into general lighting service, conventional rated lives are 1,000 and 750 hours for residence types, 750 hours for larger commercial lamps, 1,500 hours for sign lamps, and 3,000 hours for group-replacement street series lamps.

* Specification-quality lamps are products which have been made to comply with the requirements of the Federal Specifications for Incandescent Lamps.

The simplicity, interchangeability, and convenience of application that characterize incandescent lamps have led to a great variety of applications in which it has been practicable to embody most of the advances of illuminating-engineering knowledge with regard to such qualities as direction of dominant components of light, degrees of diffusion of light, intensities of light, and limitations of brightness of exposed sources. The result has been excellent advance in electric-lighting practice.

The convenience and flexibility of the incandescent lamp are illustrated in the two-filament three-light type which has attained such large popularity in portable equipment in residence lighting.

Among disadvantages of the incandescent lamp are sensitiveness to voltage fluctuations (a 5 per cent decrease in volts causes a 15 per cent reduction in light output); the production of an undesirable amount of heat incident to the lighting process; and the relatively low efficiency of light production—low in comparison with some light sources, but high in comparison with lamps of a few years ago.

Favorable qualities of incandescent lamps include practically instantaneous starting (accompanied, however, by a large short-time inrush of current to the cold filament); filament thermal lag that reduces cyclic flicker in a-c service to an extent that makes it practically inappreciable under ordinary conditions above 40 cycles per second; and close approximation to unity power factor. The ready facility with which filament lamps of different sizes may be substituted for each other must count also as an advantage for incandescent lamps. An attractive feature of incandescent lighting is the agreeable color of the light. Humans have evolved under sunlight and firelight. The daylight period has been the occasion for all kinds of activities; the firelight period is associated with comfort, safety, repose. The two form extremes of radiation that approximate black-body character. Incandescent electric lamps confront the human mind and the human eye with a light color quality that is agreeable.

INFRARED LAMPS

The radiation from 7,800 to 20,000 angstroms is sometimes called the "near infrared." The region beyond 20,000 is called the "far infrared." Glass is practically opaque to radiation of longer wave lengths than 40,000. Glass filters having high transmission in the infrared and high absorption in the visible have been developed. Filaments in drying lamps are operated usually at about 2,500 degrees Kelvin.⁷ Such filament lamps have been used successfully for radiant-energy drying in baking, heating, and evaporating moisture, and for softening, expanding, or treating materials. Sealed drying lamps of 500- and 1,000-watt sizes are equipped with cover glass of the kind mentioned.

Tungsten incandescent lamps have peaks in the infrared as shown in Table II. Wave lengths of the order of 10,000 to 12,000 angstroms produce maximum penetration of aqueous bodies. Lamps provide peak penetration at about 11,000 angstroms.

The use of radiant energy from drying lamps⁸ offers opportunity for conserving space and for effecting economies with increased production in numerous industrial drying operations. In manufacturers' catalogues drying lamps are listed in variety that appears to be quite adequate to all demands. Technical information regarding

their use is supplied in readily usable form. In the application of these lamps there is opportunity for engineering ingenuity. Since the materials and the engineering ability are available, this application of light sources rapidly is assuming great importance.^{9,10} Manufacturers' literature on the subject features, not without reason, such expressions as "The modern way to bake, dehydrate, or dry"; "faster, cheaper, and easier drying, baking, and heating."

Mercury-Vapor Lamps

The mercury-vapor arc lamp is a remarkably versatile device. Its characteristic radiation lines vary in intensity with temperature and pressure throughout a wide range. The ultraviolet spectrum lies between 4,000 and 1,000 angstroms.¹¹ Ultraviolet energy from the sun reaches the earth's surface down to wave lengths 2,900 to 2,800 angstroms. The mercury-vapor lamp can be made

Table I. Energy Input to Modern 60-Watt Tungsten-Filament Lamp

	Per Cent
Rated visible spectrum.....	7.5
Gas loss—heat convection and conduction.....	13.5
End loss—conduction by leads and support wires.....	1.2
Filament radiation (an additional 6 per cent bulb and base heat absorption is involved).....	80.8

Table II. Wave Length of Peak Radiation of Tungsten Incandescent Lamps

Color Temperature (Degrees Kelvin)	Angstroms
2,150.....	12,000
2,800.....	10,000
3,300.....	8,000

Table III. Mercury-Vapor Lamps Produced in 1942

Watts Per Lamp	Thousands of Lamps Per Year
Bactericidal Lamps	
4.....	3
5.....	10
15.....	24
30.....	2
Sun Lamps	
100.....	11
130.....	5
275.....	12
400.....	18
Various.....	5
For Illumination Purposes	
Type H	
100.....	15
250.....	21
400.....	127
1,000.....	3
Cooper-Hewitt	
All sizes.....	53

This table does not include high-power therapeutic radiators for use under medical direction and in certain industrial processes, of which it is understood that more than 5,000 were sold in 1942.

Table IV. Light-Producing Efficiencies of Principal Type-H Lamps

Lamp Watts	Rated Initial Lumens Per Watt	Lumens Per Watt at 70 Per Cent Rated Life
100.....	35.....	30
250.....	30.....	25
400.....	30.....	35
3,000.....	40.....	

Table V. Spectral Characteristics of Some Mercury Lamps

Watts	Relative Ultraviolet (Below 3,800 Angstroms)	4,358 Angstroms (Blue)		5,461 Angstroms (Green)		5,780 Angstroms (Yellow)		Continuous (Visible)		Relative Infrared (7,600-26,000 Angstroms)
		Lumens	Per Cent	Lumens	Per Cent	Lumens	Per Cent	Lumens	Per Cent	
H-1, 400	2.1	110	0.7	7,860	49.1	6,800	42.5	1,230	7.7	40.9
H-2, 250	1.2	55	0.7	3,770	50.3	3,245	43.3	430	5.7	14.6
H-4, 100	1.6	25	0.7	1,735	49.6	1,255	35.9	485	13.8	14.7
H-5, 250	4.6	70	0.7	4,630	46.3	4,040	40.4	1,260	12.6	32

to radiate within this region, and also in considerably shorter wave lengths and in longer wave lengths.

Radiation in the region 4,000 to 3,200 angstroms is most useful for photochemical effects. That between 3,000 and 2,400 angstroms is valuable for activation of vitamin *D* in sterols. The region below 2,800 angstroms is most effective in destroying microorganisms. All of these purposes are served by mercury-vapor lamps. The low-pressure lamps, with strong radiation in the 2,537-angstrom line are of value for bactericidal purposes. The sun lamps, with strong radiation at 2,967 angstroms, are effective for erythema, tanning, and antirachitic purposes. Both low- and high-pressure lamps have usefulness in the photochemical and industrial-illumination fields. The very high-pressure water-cooled lamp is a concentrated source of light, valuable for projection purposes. Certain smaller mercury-vapor projection lamps have a variety of applications, including bactericide and theater lighting.

A mercury arc in a glass tube produces illumination. Line that tube with phosphors, and it becomes a fluorescent lamp. Replace the tube with fused quartz or ultraviolet transmitting glass, and it becomes an ultraviolet radiator. Yet it is the same kind of mercury arc!

Quantities Produced. The approximate quantities of certain types of mercury-vapor lamps produced during 1942, as reported by principal manufacturers are shown in Table III.

FOR ILLUMINATION PURPOSES

Light-producing efficiencies of the principal type-*H* lamps are listed in Table IV. These lamps require some few minutes for starting and, if the circuit is interrupted, will not restart immediately. They are, of course, suitable primarily for use in industrial installations. They are often used in connection with incandescent lamps of high wattage to produce better color value and to insure against full outage. Abroad, especially in England, these lamps have been used chiefly for street lighting. In cities they were thought to complement show-window lighting nicely, while in suburbs they illuminated the green foliage pleasingly.

Color. The color of mercury arcs is so largely subjective that attempts to compare it with daylight are complicated. Buttolph¹² makes graphic comparison of an incandescent lamp, a sodium lamp, the Cooper-Hewitt lamp, and a high-intensity mercury lamp, by assigning to the spectral lines widths such that their areas are proportional to their relative intensities, and the total line areas represent the visible energy necessary to produce equal luminosities. Trichromatic sensations are hardly applicable in the case of these line-spectra sources. However, in the high-pressure mercury lamps there is shift away from shorter- to longer-wave-length energy, and a continuous

background appears in the spectrum, with betterment color quality for most illuminating purposes. Some spectral qualities of certain high-pressure mercury lamps are cited in Table V.²¹

ACTIVATION OF FLUORESCENT MATERIALS

The high-pressure mercury-vapor lamps that are catalogued as *H-3*, *H-4*, and *H-5* are of high efficiency and producing 3,660 angstroms radiation, are useful for activation of fluorescent materials used in theatrical and decorative work. They are useful too in many photoprinting applications that are dependent upon high intensity of near ultraviolet. The *H-3* lamp is being used in printing the sound track on films. The *H-4* lamp in a reflector red-purple bulb is much used for exciting fluorescence.

A phosphor designated 360 *B-L* is utilized in mercury-vapor lamps ranging from 3 to 40 watts. It converts the 2,537 mercury radiation to energy radiated between 3,000 and 4,200 angstroms with relatively little radiation in the visible spectrum. The 2,537 radiation is substantially suppressed. This lamp is useful for activating fluorescent materials and in certain photochemical processes. A four-watt d-c lamp of the type just mentioned is used for illuminating airplane instrument panels.

HIGH-PRESSURE QUARTZ MERCURY-ARC LAMPS

Ultraviolet radiation from these sources is relatively greater than in the low-pressure lamps, though the line of greatest radiation may not be so well adapted for some purposes while being better adapted for others. These lamps, operating at from 10 to 100 atmospheres with quartz inner bulb, have spectra that approach the continuous with a line spectrum superimposed. The 1,000-watt water-cooled lamp produces about 65,000 lumens initially at 65 lumens per watt or, if the auxiliary be taken into account, at about 54 lumens per watt. It is employed in the laboratory, having a life of only about 50 hours.

High-pressure quartz mercury arcs are used in various photochemical works. They are a preferred source for irradiating milk and other foodstuffs. They are employed in the synthesis of rubber and the curing of enamel coatings and patent leather, and find wide application in tests of fastness of dyes, purity of paints, and aging of fabrics. Such sources are used also in blueprint machines, in photo

Table VI. Results of Experiments With Hot-Cathode Germicidal Lamps

In a 4,000-Cubic-Foot Room

Watts Per Lamp	Equivalent to Air Changes Per Hour
30	100
15	45
8	40
4	10

Table VII. Typical Phosphors Used in Fluorescent Lamps

Phosphor	General Color	Exciting Range* (Angstroms)	Sensitivity Peak (Angstroms)	Emitted Range (Angstroms)	Emitted Peak (Angstroms)
Calcium tungstate	Blue	2,200-3,000	2,720	3,800-7,000	4,400
Magnesium tungstate	Blue-white	2,200-3,200	2,850	3,800-7,200	4,800
Zinc silicate	Green	2,200-2,960	2,537	4,500-6,200	5,250
Zinc beryllium silicate	Yellow-white	2,200-3,000	2,537	4,500-7,200	5,950
Cadmium silicate	Yellow-pink	2,200-3,200	2,400	4,300-7,200	5,950
Cadmium borate	Pink	2,200-3,600	2,500	4,000-7,200	6,150
360 BL phosphor†	Blue ultra	2,200-3,200		3,200-4,000	3,600

* 2,200 angstroms is lower limit of measurements.

† Used for exciting fluorescent chemicals, blueprinting, and so forth.

printing apparatus, in the activation of vitamin *D* in food-stuffs and in pharmaceutical preparations.

Sunlamp. Luckiesh¹³ in "Artificial Sunlight" states that in summer on a clear day at noon erythral energy is received at the earth's surface at about equal parts from the sun and from the total sky. At other times the ultraviolet from the sky exceeds that from the sun. Sunlight spectra extend down to about 2,900 angstroms. Porter¹⁴ describes sun lamps in terms of erythral power with spectral curves. The most powerful wave length in producing erythema is at 2,967 angstroms. The erythral effectiveness curve from 2,800 to 3,180 angstroms is shown.

There are five sun lamps having different radiation characteristics with the S2 lamp producing about one third of the ultraviolet that is produced by the others. Irradiation of the body is one way to produce vitamin *D*. Coblentz¹⁵ notes that radiation of 2,540 angstroms does not penetrate deeply into the skin. Erythral effects are superficial. On the other hand, radiation of 3,100 and longer beyond erythral dosage does penetrate and may produce a blister. In addition to application to the human body, experiments in irradiating farm animals and poultry have produced successful results, as, for instance, in increased production and hatchability of eggs.¹⁶ These lamps offer an alternative method of prevention and cure of rickets.

BACTERICIDAL LAMPS

Within the ultraviolet range the region 3,000 to 2,000 angstroms is considered to have germicidal value.* Bactericidal action is said to be at a maximum at approximately 2,660 angstroms, decreasing for shorter and longer wave lengths, but rising again for radiation below 2,375 angstroms. This is for the generality of pathogenic bacteria concerning which some information is available. There are known exceptions.

Within this bactericidal range the 2,537-angstrom resonance line of mercury is excellently placed for effectiveness. About half the radiation from low-pressure mercury-arc lamps is in this 2,537-angstrom band. These lamps, equipped with ultraviolet transmitting glass, therefore are an efficient and economical source of bactericidal radiations. They are available in two types as follows:

Cold cathode, known to the trade as "Sterilamp," is rated at 15 watts. It starts at about 575 volts and operates at about two-thirds that value.

Hot cathode, known to the trade as "germicidal lamps," are available in 30-, 15-, 8-, and 4-watt sizes. Except for the absence of phosphors and the use of ultraviolet transmitting glass, they are similar to fluorescent lamps. These lamps decline in efficiency with low

temperatures. At freezing, the output is 60 per cent; at 0 degrees Fahrenheit it is 30 per cent of normal.

Certain infections, including common colds, are believed to be carried by air-borne bacteria or virus. Energy radiated in the stated regions offers a practicable means of killing such bacteria. Installed in ventilating ducts, where that is feasible, or so placed as to irradiate the upper stratum of air in a room where there is fair circulation, these ultraviolet radiators offer means of purification of the air that is analogous to the purification of drinking water.

Experiments as to the lethal effectiveness of such ultraviolet radiation have been made principally with bacilli coli, a rather harmless organism having characteristics thought to be similar to those of many pathogenic bacteria. Working with these bacilli coli, experimenters have reported achievement by these means of an equivalent of air replacement of 4,000 cubic feet per minute per person, which is 10 to 15 times the actual air replacement needed to keep carbon dioxide down to a satisfactory level. It has been reported further that one of these ultraviolet radiators in an average-sized duct will kill over 90 per cent of the bacteria in the air passing through the duct at a rate of 500 to 600 cubic feet per minute.¹⁷

A single such radiator irradiating the upper part of an average-sized office is said to be capable of reducing the bacteria count as much as could be accomplished by opening all of the windows on a breezy day. Other reports are that one small ultraviolet lamp irradiating about 3,000 cubic feet of air has a sanitary effect equivalent to 50 or 100 air changes per hour.¹⁸

Irradiation of the upper stratum of the air in a room for bactericidal purposes is sometimes referred to as "sanitary ventilation."* The effectiveness of such methods is lower when humidity is higher.

In certain experiments with hot-cathode germicidal lamps the results shown in Table VI have been observed.¹⁹ There seems to be no doubt that under properly controlled conditions such ultraviolet radiation is effective in killing air-borne microorganisms and may be used to supplement other measures for the prevention of cross infection. Experiments thus far are promising and indicate the possibility of a large and useful application in the near future. In places where there is illness or where there are large assemblages of people the applicability seems immediately indicated. Hospitals, schools, theaters, passenger carriers, and the like might benefit. Since it has been estimated that an average of 400,000,000 colds a year cost the nation half a billion dollars, the prospect of being able to reduce infection through air purification is very attractive.

It is interesting to contemplate the value that these

* Mayer¹¹ notes that germicidal effects differ with different bacteria. 3,100 angstroms is a lethal radiation wave length for some, but action in other cases has been observed at 2,250 angstroms.

* A popular article describing successful results of experiments in preventing cross infections in cases of measles and colds appeared in the *New Republic* for December 15, 1941, under the authorship of Bruce Bliven. It was condensed in the *Readers' Digest* for January 1942.

bactericidal lamps may possess for occupants of heated submarines and heated cabins of stratosphere airplanes. Regions inhabited by mermaids and gremlins may be provided with California climate!

Sterilization. Ultraviolet radiators are entering into use in hospital operating rooms for prevention of cross infection and of infection in wounds. It is said that a six-to-one reduction in the incidence of wound infections in certain types of operations has been shown in records of two hospitals. Such lamps for use in operating rooms, nurseries, and hospital wards, where they are used under medical supervision, are listed by the American Medical Association as "Accepted." However, sources radiating appreciable energy of wave lengths shorter than 2,800 angstroms are not recommended for use by laymen for therapeutic purposes.

Smallest of the ultraviolet lamps is an arc in a quartz tube within a container that is about $10\frac{1}{2}$ by 3 inches. These are provided for treatment of slow-healing wounds, abscesses, ulcers, and so forth.

Miscellaneous Applications. Sanitizing uses to which ultraviolet radiators are being applied include:

Meat storage places	Sterilizing special canners' sugar
Restaurants	Hospital bathrooms
Bakeries	Industrial washrooms
	Water sterilization

Conservative Application. In the realm of prophylactic and therapeutic practice, as well as in the field of health generally, a great deal of conservatism is required from engineers. A suggestion as to health benefits attributable to ultraviolet radiation is likely to give rise to ill-founded and extravagant commercial claims by irresponsible people. Much of the experimentation in this field has been carried on by commercial interests that are desirous of selling equipment for this purpose. Engineers know leaders in this experimental field and respect them. Others, however, may draw from their work far-reaching conclusions that are hardly justified. It would appear that there is a need for more independent disinterested experimentation in ultraviolet applications for prophylactic and therapeutic purposes. Indications point to an important and growing field of usefulness for these sources of radiation. It is important that it be developed conservatively. Ultraviolet radiators are no panacea for either prevention or cure. They are useful devices that may be expected to fill an increasingly important place in the future.

Sodium-Vapor Lamps

Unlike other lamps, the sodium lamp^{20,21} is not at all versatile. No matter how it is treated, it sturdily insists upon radiating its light at 5,893 angstroms. Before the war these lamps were being sold at a rate of about 11,000 a year. They are used for highway lighting and lighting of traffic intersections where a different effect is sought in order to keep motorists alert. They have also been used for lighting railway yards and airfields. The monochromatic light should have value wherever high visual acuity is involved and where the color characteristic is unobjectionable. Since the radiation is at a wave length close to that of maximum eye response, the sodium lamp is a highly efficient illuminant, the 10,000-lumen lamp producing light at about 50 lumens per watt with auxiliary loss included.

Fluorescent Lamps

The genealogy of the fluorescent lamp traces back to the Cooper-Hewitt mercury-arc lamp²² and the Claude neon tube.²³ Electrically it is an arc discharge through a low pressure atmosphere of mercury vapor and rare gases. The literature of the art records the distinguished development of the mercury-arc lamp into regions of higher and higher temperatures and pressures with expanding field of usefulness. It records also the advances in sign lighting including the employment of gases or vapors other than neon, to produce the ingenious colorful outdoor displays with which we in America are most familiar. In the last few years these two illuminants, while continuing to serve with increasing effectiveness in their distinctive fields, have been developed through the addition of fluorescent materials, called phosphors, to afford valuable service in the field of general illumination.

As a result there are now mercury-vapor lamps from which but little of the light produced in the characteristic mercury-radiation lines of the visual spectrum emerges but from which a relatively large amount of light is radiated from the fluorescent materials that are activated by the ultraviolet energy of the mercury arc.

Ballasts. To stabilize the arc some form of ballast is required. Probably the simplest form of ballast is the series resistance, as now used in d-c service, but, because of its energy consumption and consequent reduction in operating efficiency, this arrangement finds little use. The most commonly used ballast is an inductive reactance, obtained either directly in the form of an iron-core choke or indirectly through a high-leakage transformer. Both of these arrangements unless modified give operating circuits of low power factor.

Starting. Two methods currently are employed for striking the arc:

- To provide a special initial ionization of the arc stream.
- To apply an initial voltage higher than operating voltage.

The first was developed in mercury-vapor-lamp practice; the second in operation of gaseous-discharge electric-sign tubes.

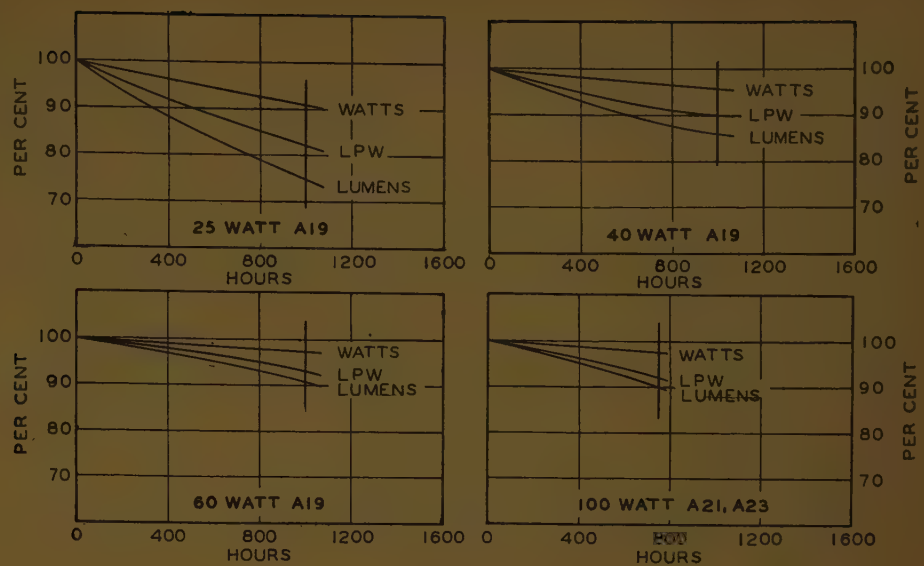
Superior Efficiency. The greatest advantage of fluorescent lamps over the generally used incandescent lamps is the production of two or three times as much light for the same expenditure of watts with less accompanying heat. This makes practicable the attainment of the higher levels of illumination that production efficiency demands where efforts are dependent upon visual ease. And this important objective can be attained without overburdening existing wiring systems or with lesser wiring costs in new systems. Furthermore it makes available an abundance of light without undue elevation of ambient temperatures and without handicapping air-conditioning systems.

Output Maintenance. All fluorescent lamps containing mercury depreciate in light output as they operate. The rate of depreciation varies for tubes of a given diameter with the current density and other factors.

COLOR OF LIGHT

Synthetic fluorescent materials have been developed to produce light of a great variety of colors. These are mixed as desired. The generally reported phosphors as commonly used in fluorescent lamps are listed in Table VII.²⁴

Figure 5. Performance characteristics of specification-quality tungsten-filament incandescent lamps



The most largely used fluorescent lamps are of the types designated "white" and "daylight," respectively. The white lamp produces light of a color that has found wide acceptance in industrial and commercial installations. It blends well with natural light. Because of the one-tenth elemental mercury radiation, it has a barely perceptible yellow-green cast that renders it unsuitable for some color-critical purposes. The light of the daylight lamp, second in popularity, has a similar characteristic but is stronger in the blue and less acceptable for use in places of assemblage.

A fundamental difference between light of fluorescent lamps and either daylight or light of incandescent lamps is the presence in the former of the spectral lines of the normal mercury discharge and a deficiency in the deep red.²⁵

The color difference is somewhat difficult to depict. In Figure 6 a comparison is made between spectrophotometric curves of

3,500-degree-Kelvin black-body radiator²⁶
 300-watt tungsten-filament lamp (2,905 degrees Kelvin)²⁷
 3,500-degree-Kelvin fluorescent lamp²⁸
 Noon sunlight²⁹

The mercury-line radiation is superimposed upon the continuous spectrum of the light from the phosphors. The vertical bars around lines representing, respectively, wave lengths 4,047, 4,358, 5,461 and 5,780 angstroms are adjusted so that the enclosed area upon the spectral curve indicates the magnitude of the energy radiated in these respective lines. Light of day and that from incandescent sources lie close to the locus of black-body radiation. The light from fluorescent sources has distinctive characteristics. The effect of the yellow-green mercury lines is to exalt the brilliance of corresponding yellow and green pigments to a degree that is not experienced in other light of equivalent synthetic ocular value. Red pigments generally are dull under fluorescent light.

A so-called "soft-white" lamp, designed to provide more acceptable appearance of meats, foods, complexions, and so forth, was made prior to the war but has been eliminated as a part of war curtailment. Its light contained more of the orange and light red elements and emphasized less the yellow-green colors. At a loss of about 25 per cent in efficiency there was achieved a color of light that for

many purposes was pleasing. When its manufacture will become practicable again, something of the kind may be expected to be placed on the market.

Such information as is available indicates that there is no material change in the color of light from fluorescent lamps throughout their operating life.

Cyclic Flicker. In lamps that operate on 60-cycle current, the arc is extinguished 120 times a second. The visible radiation from the phosphor that produces blue light varies almost instantly with the change in activation. The light from other phosphors lags a bit but follows the variations in activating energy very largely. The result, on alternating current, is a pronounced cyclic flicker of light modified by a slight color flicker. On 60-cycle circuits the relative cyclic flicker expressed in per cent deviation from mean light output has been found to be

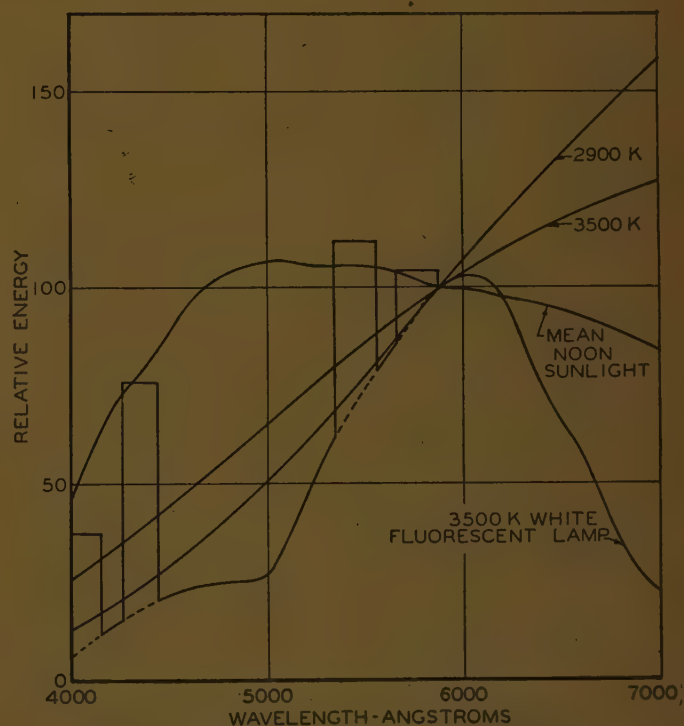


Figure 6. Comparative spectral distributions

Table VIII. Relative Cyclic Flicker on 60-Cycle Circuits
Per Cent Deviation From Mean Light Output

Light Source	Relative Cyclic Fluctuation
100-watt tungsten-filament lamp.....	5
Red fluorescent lamp.....	10
40-watt tungsten-filament lamp.....	13
2 white fluorescent lamps on phase-offsetting auxiliary.....	16
Green or pink fluorescent lamp.....	20
Gold fluorescent lamp.....	25
2 daylight fluorescent lamps on phase-offsetting auxiliary.....	25
Single white fluorescent lamp.....	35
Single daylight fluorescent lamp.....	55
Single blue fluorescent lamp.....	90

approximately as shown in Table VIII.³² Uncritical observers may ignore such light flicker, especially in installations in which the need for refinement in lighting results is not very urgent. In critical service, however, it requires to be modified to lessen its stroboscopic effects.

The cyclic light flicker may be reduced to an unobjectionable level where several lamps are used to illuminate the same area if, polyphase service being available, the several lamps are connected to different phases, thus offsetting the maximum-minimum extremes of light production.* This arrangement, however, leaves the power factor unsatisfactorily below unity and in need of correction.

Brightness. The brightness of white and daylight fluorescent lamps is close to the acceptable limit of exposure in the field of view. It is so close indeed that in the industrial installations where ceilings are of good light reflectance and the fluorescent lamps are mounted high and cover a large part of the ceiling area, some think it acceptable to operate the lamps unshielded. It is the consensus of opinion, however, that in other installations the lamps should be shielded to reduce their brightness to acceptable values. This becomes especially important where exacting visual tasks are performed and where the lamps may enter into the ordinary field of view.

Vision Under Fluorescent Lighting. Through experiments and reasonable deductions, it has been concluded that there is no appreciable difference in vision attributable to the differences in quality of light from, respectively, "daylight" fluorescent lamps and tungsten-filament lamps.³⁰

Design. Apparently in several important aspects of fluorescent lamp design, there is an optimum above and below which less favorable results are obtained. This seems to apply to tube dimensions, arc current, activating energy, combination of phosphors, and so forth.

In Critical Installations. Humming noises from auxiliaries and radio interference are aspects of fluorescent-lighting equipment that must be guarded against in critical installations, as in home-lighting service.

Types of Fluorescent Lamps. There are available currently three forms of fluorescent lamps evolved through the lines of descent that have been described: They are, respectively, the multiple low-voltage hot-cathode lamps; the higher-voltage cold-cathode lamps, and the rectified low-voltage hot-cathode lamps. Statements in the foregoing discussion of "Fluorescent Lamps" are generally

* For other means of obviating objectionable flicker, see discussion under multiple low-voltage hot-cathode lamps.

applicable. On the following pages are comments that apply only to one or another of the types.

MULTIPLE LOW-VOLTAGE HOT-CATHODE FLUORESCENT LAMPS

Some of the electrical features of these lamps are considered in the discussion of mercury-vapor lamps. The range of these fluorescent lamps for general illumination purposes at present is from 15 to 100 watts. The 15- to 40-watt sizes, inclusive, fit standard lamp holders. The larger-size lamps fit into Mogul lamp holders. These lamps, however, are not generally interchangeable as to size. Because of different lengths, spacings between lamp holders are different. There also are four-, six-, and eight-watt lamps that fit into miniature lamp holders.

Transformers. The 15- and 20-watt lamps that do not require higher than line volts for starting are operated without transformers. The 30- and 40-watt lamps, requiring a minimum of 200 volts open circuit for dependable starting, are provided with transformers for operation on 120-volt circuits. They may be operated without transformers on the 208-volt supply lines that commonly are available in both industrial and commercial installations. The 100-watt lamp is sometimes operated without transformers, the lamps being connected two in series and operated with proper ballasts from a 265-volt source that is available in many industrial installations. (Phase voltage corresponds to a 460-volt four-wire three-phase supply.) Special four-lamp ballasts are available for this application.

Ballasts. Growing out of practice in the operation of high-intensity mercury lamps³¹ has come the operation of a pair of lamps on a ballast in which a capacitor is used to provide a lead current for one lamp that is out of phase with the lagging current of the other lamp. A compensator is placed in this lead lamp circuit to insure adequate preheating of the electrodes. Such operation insures both satisfactory power factor and adequate reduction of the magnitude of light flicker. From the better power factor come reduced wiring costs and advantage for generating and distributing equipment. From the reduced light flicker come diminished stroboscopic effects that otherwise would be objectionable in critical installations. This type of corrected auxiliary is very generally used.

The four-lamp ballast for 100-watt lamps previously mentioned accomplishes similar power-factor and light flicker corrections. It achieves a small gain in lumens per watt of the lamp and its equipment.

Flicker Correction. In discussion of fluorescent lamps in general, the magnitude of cyclic fluctuations of the light of fluorescent lamps was compared with that of incandescent lamps. The advantage in light-flicker reduction accomplished through the use of twin lamp ballasts is shown in Table VIII.

Starters. A starter in the circuit of each lamp delays for a few seconds the application of voltage while the electrodes are being preheated. This delayed start is not necessary but is provided in the interest of good performance of the lamp. Failure of the lamp usually occurs through decline of the emissivity of the electrode. The rate of this decline is greatly affected by the number and frequency of starts. In the laboratory with one start every three hours, a life of well over 3,000 hours is obtained. A starterless ballast is practicable but in the present stage of

development is not advisable because of impairment of lamp life.

Because the starting current is about double the operating current, the ballast of fluorescent lamps will become overheated if a deactivated lamp is permitted to remain in the circuit. To obviate possible difficulties, a type of starter recently put into production includes a thermal switch in series with the starter timing switch. When the fluorescent lamp fails and the starter makes a few attempts to establish the arc, the resultant heat opens the thermal switch which remains open until the failed lamp is replaced. This eliminates the flow of current through the lamp auxiliary, reducing the watts dissipated at the transformer. An extinguished lamp seems a more acceptable signal for replacement than does a blinking lamp. And the likelihood of damage through elevated temperature in the ballast is eliminated. These "no-blink" starters are now available for 40- and 100-watt lamps. They are available in both the automatic and the manual reset type.

Efficiency. The optimum operating temperature for hot-cathode fluorescent lamps is an ambient of the 100 to 120 degrees Fahrenheit range. Above and below this range the output and the efficiency fall off. Only 25 to 35 per cent of the total energy dissipated is radiated from fluorescent lamps in the infrared region. Amick²⁴ analyzes the 40-watt input as given in Table IX.

It is evident that in comparison with the gas-filled tungsten lamps, in which 60 to 75 per cent of the energy is radiated in the infrared region, the light from fluorescent lamps is relatively cool light. According to this analysis, about 18.5 per cent of the applied watts is converted in these fluorescent lamps into light within the visible spectrum.

The rating of these lamps as to light-output efficiency is customarily based upon the watts delivered to the lamp, exclusive of that absorbed in the auxiliaries, which for two lamps on a "tulamp" ballast is about 17 watts. This form of rating is used presumably because the watts dissipated in the auxiliaries depend upon the type of auxiliary used. On this basis the 40-watt white lamp, after the decline of its initial 100-hour period, produces approximately 52 lumens per watt. The manufacturers seem to feel that a ten per cent increase is probable in this efficiency of light production. The depreciation in efficiency at 70 per cent of rated life is about 15 per cent. This the manufacturers believe that they are on the way to improving quite appreciably, perhaps cutting the rate of decline almost in half.

These fluorescent lamps are quite sensitive to changes in temperature of ambient. For specimen lamps of several sizes ranging from 15 to 100 watts as produced in 1941, the variations under reasonable test conditions are as shown in Figure 8. Within the usual range of indoor temperatures, say 50 to 90 degrees Fahrenheit, variations in efficiency are not more than five per cent.

The sensitiveness of these lamps in this respect is a nightmare to photometrists who seek reproducibility of test results. With temperature and other conditions well-controlled in a laboratory, variability due to changes in the ambient temperature is minimized in the case of bare lamps. When, however, these lamps are used in any kind of housing or in a reflector, the temperature of the ambient varies with the type and position of the enclosure. In such case it is important to be sure that the lamp is operated in the same position as that in which it will be used and to

make photometric measurements without alteration of that position.

Use of the hot-cathode fluorescent lamps outdoors in cold weather is inadvisable unless special precautions are taken to avoid starting troubles.

Applications. The use of fluorescent lighting was growing by leaps and bounds until the war put an end to its development except for Government and war-production purposes. In the last two years new installations have been limited chiefly to such uses. Most recent experience therefore has been in industrial and Government office-building lighting. When materials and manufacturing facilities are released from war service, it is probable that the rapid increase of prewar months will be resumed and accelerated in industrial and commercial lighting fields.

Many people also are looking for extensive development of fluorescent lighting in residences. In the utility rooms of the home, as the kitchen and laundry, fluorescent lamps may be expected to find ready application. It seems apparent that in new or reconstructed buildings long slender sources can be embodied architecturally to secure effects that may be wanted in some cases. High voltages, however, are to be avoided. When portable lamps and attached lighting fixtures are considered, the large physical dimensions of the fluorescent lamps required to secure adequate light flux seem likely to intrude as a difficulty. Small sources that lend themselves to dainty and graceful structures for small rooms are desirable. Circular fluorescent lamps that may become available will approach this objective, but it will be difficult to get enough light from them to provide general illumination.

In case these difficulties are overcome, there still will remain the question as to the desirability in most cases of trying to substitute fluorescent for incandescent lamps in the home. If the fluorescent-lighting equipment is to be well done and to serve for satisfactory lighting, it seems likely to be more costly than incandescent lighting. It will be more complicated, and the acceptability of the color of fluorescent light remains to be established. Doubtless when the war is over, light of color that will be more pleasing for residence use than is the present "white" lamp will be made available. Perhaps the former "soft white" will be restored. So long, however, as the radiation in the characteristic mercury lines produces something like ten per cent of the total illumination, the acceptability of fluorescent light for other than utilitarian rooms of the home may be questioned.

Prospect as to Types of Fluorescent Lamps. The trend has been toward bigger and better fluorescent lamps, but the optimum size may already have been reached. As with illuminants in general, economical lighting is achieved through standardization upon a few types that can be produced in large quantities. As always, there is a demand

Table IX. Analysis of 40-Watt Input of Hot-Cathode Fluorescent Lamps

	Conversion of Energy Within the Lamp (Watts)	Ultimate Conversion (Watts)
Light.....	0.9.....	7.4
Ultraviolet radiation (55 per cent at 2,537 angstroms).....	22	
Heat.....	17.1	Radiated 10.9 Convected and conducted.....21.7

for specialty lamps to meet special requirements. As always too, something that is different can be sold merely on the ground of difference. Conspicuous among the desires that have been expressed is that for circular lamps, already mentioned. The manufacturers report that they can make such lamps when the war is over, but they apprehend that the cost will be relatively high, and the demand for them may be less than some people expect.

It might appear that the production of circular fluorescent lamps is likely to be attended with considerable difficulty. There will be questions as to the kind of ballasts and starters to be used, and as to provision for minimization of radio interference and cyclic flicker, as well as for good power factor. The type of lamp holders to be used and their location may offer some difficulty. It would seem also that the manufacturing process might be more complicated in some particulars than for straight-tube lamps. On the whole, higher cost and possibly less satisfactory performance are to be expected from circular lamps.

Cooper-Hewitt Rectified Fluorescent Lamps. In the original Cooper-Hewitt mercury-vapor lamp²² a-c operation was accomplished by resorting to a rectifying circuit that provided a pulsating d-c discharge through the lamp. Recently this type of lamp has been equipped with phosphors for production of fluorescent light for industrial installations. There are 85-watt lamps rated at 4,000 lumens, 47 lumens per watt for the lamp alone. These lamps are available in two colors, the one called blue-white and the other called industrial white. The blue-white lamp "emphasizes the cooler end of the spectrum." The industrial white lamp gives a somewhat whiter light. A capacitor in the circuit contributes to producing a 90 per cent power factor. The maximum over-all length of the lamp is 57½ inches. The length of light source is about 52 inches. The diameter of the luminous part of the tube is 1½ inches. The lamp has a cathode and a pair of anodes. There is a flow of current through the lamp, first, for a half-cycle from one anode and then for the other half-cycle from the other anode to the cathode. Starting voltage is approximately 2½ times the normal operating voltage. There is a delay in starting for a few seconds in order to permit the cathode to attain emitting temperature. A bimetal delay element protects the lamp until the cathode attains satisfactory temperature. It is understood that manufacture of fixtures for these lamps is suspended for the duration.

HIGH VOLTAGE-COLD-CATHODE FLUORESCENT LAMPS

The high-voltage cold-cathode fluorescent lamps²³ are the immediate outgrowth of gaseous-discharge sign equipment developed in recent years as small-diameter tubes, filled first with neon and then with mercury or argon or helium to produce light of different colors for display purposes. They have been evolved out of outdoor sign-lighting practices. The availability of efficient phosphors for lining the long small-diameter tubes employed in sign work made it practicable to utilize such tubes in providing general illumination.

Electrical Features. These tubes are operated upon transformers providing secondary voltages up to 15,000, sufficient voltage being provided for striking the arc. The transformers usually are of 60- to 120-milliampere capacity. Relatively large electrodes are used, usually in the form of metal cylinders. These operate usually at about

150 degrees centigrade. The starting voltage is perhaps 1½ times the operating voltage.

There is a drop of about 130 volts per pair of electrodes operating at 100 to 120 milliamperes. The current must be kept low in order that the watts loss at electrodes may not be excessive. Yet for satisfactory efficiencies one manufacturer recommends that the 25-millimeter tubes should not operate at less than 100 milliamperes, and the 20-millimeter tubes at not less than 90 milliamperes.

As the voltage drop at the electrodes of long tubes is no greater than that of short tubes, recourse is made to long tubes and high voltages where attainment of good efficiency is sought. At a given current the voltage drop for a tube of large diameter is smaller than for a tube of smaller diameter. In the interests of efficiency the diameter of the tube is made small in order that the current per unit of cross section may approach the optimum. These relatively high voltages for starting and for operation formerly were frowned upon for indoor service. However, subject to precautionary restrictions, they are permitted in the National Electrical Code, with the result that high-voltage cold-cathode fluorescent lighting has entered quite extensively into industrial- and commercial-lighting service. Whether or not required, it would seem to be desirable to install some form of automatic circuit breaker on the primary side of the transformer to operate in case the lamp circuit be opened.

The cold-cathode high-voltage lamps start instantly without need for preheating devices.

High-voltage cold-cathode fluorescent lamps generally have been assembled in the installation, with total length of tubing adapted to the space to be illuminated. Tubes lined with fluorescent powders have been welded and assembled as required. Often there has been reliance on the ceiling as a reflector. This sometimes presents an appearance that is an improvement over that of fluorescent units having their own reflectors. But it affords less ease of cleaning and sacrifices light redirection in most cases.

These long slender tubes lend themselves readily to a wide field of custom construction. With the skill developed in sign work the manufacturers may be expected to show facility in providing a variety of shapes and sizes of tubes for special purposes, including conformity with architectural contours.

Performance. Custom assembly of tubes from various sources is subject to variables that make it difficult to arrive at typical performance statistics. There has been very little standardization of a kind that makes possible precise statements as to efficiencies. These may vary through a considerable range, being involved with extent of trans-

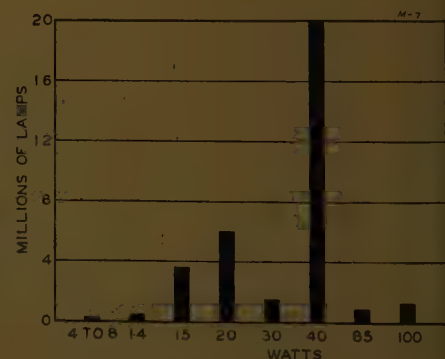


Figure 7. Hot-cathode fluorescent lamps produced in the United States in 1942

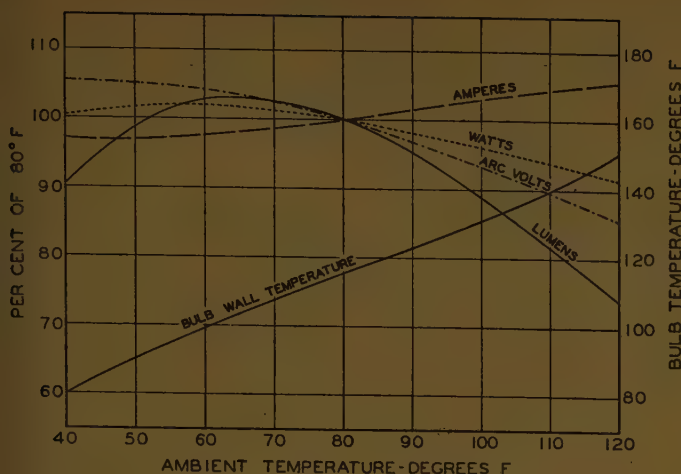


Figure 8. Effect of ambient temperature on characteristics of hot-cathode fluorescent lamps

former loss, voltage, and current. Best efficiency of light production, other things being equal, is found in longer lamps.

Among the most commented-upon installations is that of the I-T-E plant in Philadelphia, in which, after a period of operation, light was found to be produced at a rate of about 266 lumens per foot from tubes operating at about 100 milliamperes. The efficiency, including a 12,000-volt transformer loss, was about 39 lumens per watt. An average of about 35 foot-candles of illumination was produced.

Generally speaking, the brightness of these tubes is of about the same order as that of 40-watt low-voltage hot-cathode lamps. The light produced per foot is about one half, and the projected area of the smaller-diameter tubes is less.

The length of life is dependent somewhat upon the current density, but in practice has been found to be very long—several times that of the life of the low-voltage hot-cathode lamps. Whether this long life is or is not an advantage is a question. It reduces maintenance cost, but the very lack of maintenance may accelerate the rate of decline of useful light output. That decline, aside from dust obstruction, as in the case of all mercury-vapor lamps, is something to be considered. It may result after a long life in a lumen output reduced to two thirds of initial. This will raise a question of an economical “smashing point” before expiration of normal hours life.

A Standard Unit. The recently organized Fluorescent Lighting Association is engaged in standardizing cold-cathode units that can be produced in complete form in factories and shipped ready for installation. These include an eight-foot unit, the luminous part of which is about seven feet, nine inches, in length. The tubes are 20 or 25 millimeters in diameter. These standard tubes may be connected in series on one transformer with power-factor correction in any number of tubes from 2 to 12. Twelve of these 93-inch tubes will operate on a 12,000-volt transformer, the operating voltage being approximately two thirds of the striking voltage. There are other tubes being standardized of the following sizes:

84-inch, known as the seven-foot lamp
76-inch, known as the six-foot lamp
52-inch, known as the four-foot lamp

Some manufacturers are understood to be developing a

system of ballast and pairs of cold-cathode lamps utilizing the same lengths of lamps as for the series arrangement, but perhaps adding an 18-millimeter tube in the 76-inch lamp.³⁴ These will be corrected both as to power factor and flicker. The different lengths of lamps will not differ much in light output but will differ principally in brightness.

General Considerations

ILLUMINATING ENGINEERING

After the war the engineer will have at his disposal a rich assortment of illuminants with which to contribute to the efficiency of industry and business, to the safety of traffic, to the beauty of decoration, and to the comforts of living. Abundant low-cost reliable sources offer favorable opportunity for accelerated development of the application of light. Illuminating engineering practiced as a peaceful art is one of those enterprises that offers advantage for everybody affected—the engineer, the manufacturer and distributor, the supplier of power, and, most important, the public. It is therefore a favorable circumstance that so many varied and effective sources of light are or will be available.

PROPRIETY IN REPRESENTATIONS

Some of the effects of radiant energy are not easily ascertained or measured. They are involved in recondite knowledge that is obscure to the public. The public easily may be confused as to these effects and is likely to be misled by glib representations having a pseudoscientific appearance. For instance, it is possible to represent almost any different kind of radiation that affects the visual organs as being “easier on the eyes” and to get a certain segment of the public to acquiesce in the assertion and to reassert it quite irrespective of the facts. Invisible radiation is even more incomprehensible to the public. It shares with real medicines and quack nostrums the influence of the faith curve. If it be represented to the public as a valuable prophylactic or therapeutic agent applied in certain cases of disease, some part of the public will accept the statement and feel convinced that its experience has confirmed the assertion, quite irrespective of the facts of the case.

Electric energy converted into radiant energy is rendering immense services to the public. It is likely to be more rather than less serviceable in the future. Strong representations as to its value and usefulness may be made with full propriety and with public benefit. But misrepresentations can only impede its growth in usefulness.

Those who produce light sources are among the industrialists and engineers who have had to forsake the ways of peace to put down the threat of aggressor nations against our way of life. When this menace shall be destroyed, they will turn back to the further development of light sources. Then if care is not taken, they may find the situation confused by misrepresentation in these matters that the public does not understand.

It appears to devolve upon engineers, both as an opportunity and as a duty, to do everything that is practicable to encourage valid significant representations regarding light sources in order to afford the public best practicable guidance. The engineering profession and the lighting industry ought to earn and safekeep a high degree

of public confidence in its assertions. Means should be found for discriminating between valid reasonable representations and those that mislead.

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34. Low-Voltage Cold-Cathode Fluorescent Lamps, Rudolph Hultgren. *Lighting and Lamps*, November 1943.



Continuous rows of twin 40-watt fluorescent units illuminate this modern industrial plant to a level of 30 foot-candles. Mounting height is 22 feet and spacing between rows $13\frac{1}{2}$ feet

Enemy Army Communications Equipment

ROGER B. COLTON

A MERICAN engineers have been instrumental in giving to the United States Army and to the Signal Corps of the Army the best equipment in the world. Although engineering for civilian needs is very different from engineering for military needs, and most American engineers have spent a lifetime in civilian engineering, they have learned within a brief period of two or three years to design equipment to meet military needs and are now, in fact, military engineers.

That we now have the best communication equipment in the world is due principally to their efforts, both in the way of design and in co-operation with communication agencies of the Government. The magnitude of the task we have accomplished together is illustrated by the fact that the largest annual appropriation for the Signal Service of the Army during World War I was \$83,201,000, whereas during the fiscal year ending June 30, 1943, the appropriation amounted to more than \$5,500,000,000—66 times as large. Another illustration of our accomplishment lies in the fact that of the 200 principal items now being delivered to the Signal Corps, 115 were developed and standardized since July 1941. Communications have been furnished to meet the needs of the slow pace of the foot soldier and the 400-mile-per-hour speed of the Air Force pilot. These are our accomplishments.

We will turn now to the accomplishments of the enemy. The first enemy equipment to be analyzed by our engineers was the German airborne radio-communications set, *FuG 10*. The German abbreviation *FuG* means Funk Gerät, a collection of radio apparatus or, in general, what we know as a radio set. The *FuG 10* is used in German bomber and reconnaissance aircraft, including the Junkers 88 and the Heinkel 111. The complete set consists of a long-wave transmitter and receiver, a short-wave transmitter and receiver, direction-finding equipment, intercommunication amplifiers, blind-approach equipment, and associated dynamotors and control boxes. The *FuG 10* is capable of operation up to 1,000 miles on continuous wave with favorable conditions.

The two receivers, *EK* and *EL* are similar except for their frequencies, which are 300 to 600 kilocycles for the long-wave receiver and three to six megacycles for the short-wave receiver. The *E* stands for "Empfänger," which means "receiver," while the *K* stands for "Kurz" or "short," that is, short-wave. (In a similar manner transmitters are designated by a large letter "*S*," standing for "sender," and "*K*," again for "short.") The circuits are both conventional superheterodynes. The standard Telefunken-type *RV-12P* 2,000 tube is used. *R* means tube, *V* means amplifier, 12 is the filament voltage, *P* signifies pentode, and 2,000 is the transconductance. Both receivers have four-spot frequencies that can be set by a cam-click mechanism on the main tuning condenser. The receivers are used mainly for continuous-wave or modulated-continuous-wave reception. The

Captured enemy communications equipment which has been analyzed by the Signal Corps Laboratory is described and is compared with American-made equipment in this first complete discussion of enemy signal apparatus to be made public by the Signal Corps.

intermediate frequency of the long-wave receiver is 140 kilocycles, and of the short-wave receiver, 1,400 kilocycles.

The high-frequency oscillators are stabilized by means of temperature-compensating condensers. The radio-frequency and intermediate-frequency

coils are all of the iron-core variety. No automatic volume control is incorporated. A test socket is available on the front panel for checking operating voltages. The dynamotor voltages supplied are 12 volts for the heaters and 200 volts at 40 milliamperes for the plates.

The two transmitters used, *SK* and *SL*, are also similar, except for their frequency ranges which are 300 to 600 kilocycles for the long-wave transmitter and three to six megacycles for the short-wave transmitter. Both units incorporate a master oscillator and two amplifiers in parallel. Type *RL-12P* 35 tubes are used in all stages. The ratings of these tubes are included in their nomenclature. *R* means tube, *L* means power, 12 means filament voltage, *P* means pentode, and 35 denotes plate and screen dissipation (30 watts on the plate and 5 watts on the screen). The tuning of the two circuits is accomplished by iron-core variometers ganged together and controlled by a single knob. As in the receivers, four preset spot frequencies are also available, and test sockets are provided on the front panel to measure existing potentials. The dynamotor supplies plate voltage of 600 volts at 150 milliamperes. The emission is continuous wave only. However, in recently captured units radiotelephone has been added by grid-modulating the power-amplifier tubes. Output was measured as 65 watts, an efficiency of approximately 65 per cent. Frequency stability was found to be excellent. Fixed and trailing wire antennas are available to the radio operator and are tuned by remote-antenna-matching units by the use of Selsyn motors.

The *EZ2* direction-finder receiver is used in conjunction with the *FuG 10* and is adapted from the commercial German Telefunken direction finder of prewar days (1933) with few modifications. The frequency coverage is 165 to 1,000 kilocycles in two bands. The services provided are visual homing, aural homing, direction-finder bearings, and all-round communication. A conventional sense antenna is used in conjunction with an iron-core loop. The receiver is operated by the navigator who has mechanical remote controls located at his feet. The remainder of the equipment comprises local- and remote-control boxes, interphone amplifier, and dynamotors. These instruments have been designed to give complete control facilities where they are needed, and they accomplish this purpose.

The newest German airborne command set, the *FuG*

Essential substance of an address presented at a joint IRE-AIEE session of the AIEE winter technical meeting, January 27, 1944, in New York, N. Y.

Major General Roger B. Colton is chief of the engineering and technical service of the Signal Corps, United States Army, Washington, D. C.

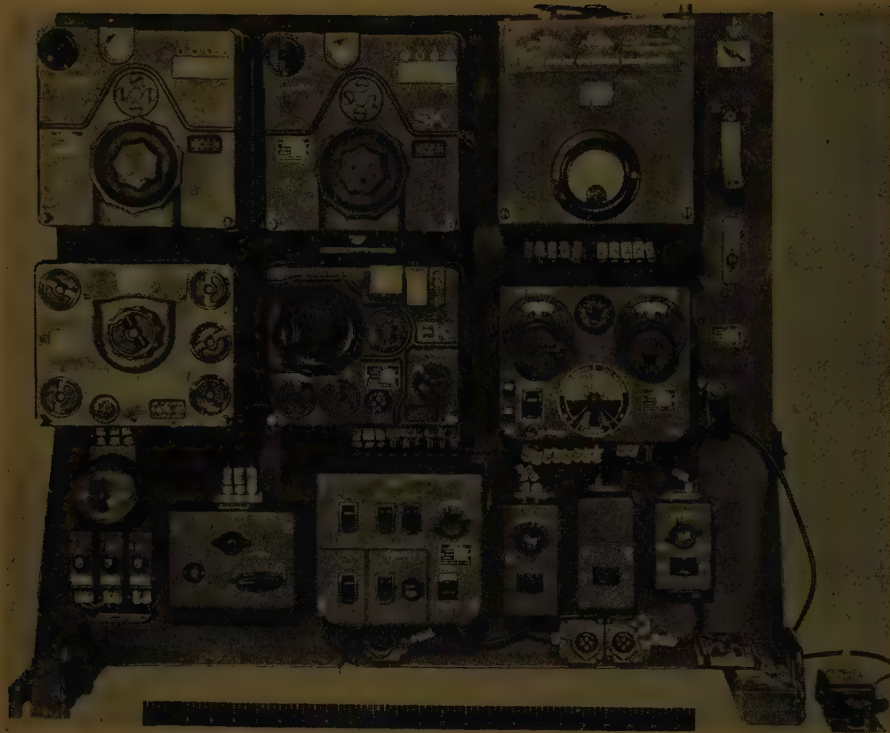


Figure 1. Test panel for German air-borne radio-communication set FuG 10

16Z, is installed in all the newer bomber and fighter aircraft. The frequency coverage of the transmitter and receiver is 38-42 megacycles, with four spot frequencies set with click stops similar to the *FuG 10* transmitters and receivers. In most installations, the *FuG 16Z* cannot be controlled locally in flight. We have found recent sets which provide for remote tuning of the receiver by the addition of a tuning motor and gang condenser. This enables the pilot to tune in to a station that may be off frequency a few kilocycles. Tests have proved this set capable of operation up to 250 miles at an altitude of 25,000 feet. Recent reports have noted an additional tuning mechanism and loop to facilitate navigational aid to the pilot.

The receiver *E 16Z* is a nine-tube superheterodyne. Only one type tube is used, the *RV-12P 2,000*. This tube is a radio-frequency pentode which is connected as a diode, triode, and pentode, as the occasion demands. The intermediate frequency is 3,000 kilocycles. Transmitter *S16Z* utilizes two *RL-12P 35* transmitting tubes in a conventional modulated-output power-amplifier circuit. Output was measured as four watts, with a plate voltage of 400 volts or 210 milliamperes supplied back to the receiver and transmitter from the dynamotor unit. The oscillator circuit incorporates negative-temperature-coefficient condensers for frequency stability. The output is fed to the antenna-matching unit through a concentric cable. The modulator, located between the transmitter and receiver consists of two *RV-12P 2,000* tubes in a two-stage circuit, one being the grid-modulator tube and the other the power-amplifier tube of the transmitter.

The German Notsender *NS 2* sea rescue set is crystal-controlled and operates on 500 kilocycles, the international distress frequency. It sends an SOS. automatically. It can also be keyed manually. The power output is approximately 2.5 watts. The *NS 2* antenna

is hoisted by a balloon inflated by a hydrogen generator, which is activated by being placed in water. If a wind of seven miles per hour or more is blowing, a box kite is used in place of the balloon. The German *NS 2* sea rescue set is the prototype of the American *SCR-578*.

In general German airborne electrical design is sound but not advanced. The mechanical design, incorporating die castings and specially designed parts, is of excellent quality. The primary design, with magnesium die castings fitted together with dowel pins and electrical plugs and jacks, is to facilitate easy servicing. An outstanding feature which becomes apparent upon examination of the airborne equipment is the neat cabling, which is "snaked" through in an orderly fashion and also is color-coded for ease in rewiring.

One thing the Germans have done to attain mass production is to standardize. In certain instances chassis are only partly filled with parts, a condition which indicates that an

identical chassis is used for other installations. Tubes also have been standardized. Most of the German installations use the *RV-12P 2,000* radio-frequency receiving tube or the *RL-12P 35* power-amplifier tube. Of the 31 tubes used in the entire radio set *FuG 10*, these two types are the only ones used.

One of the first Japanese sets received by the Signal Corps was a receiver, transmitter, and dynamotor removed from a Zero fighter which crashed on a Pacific island in February 1942. The receiver—seven by nine inches—is a five-tube superheterodyne of obsolete construction compared to Signal Corps standards. The transmitter utilizes a crystal oscillator modulated by a single tube. Both tubes in the transmitter were marked *UX 47*, which is identical to the American *UY 47*, except that the plate lead is brought out of the top of the glass envelope.

The entire installation represents a command set of very crude construction. The coils are wound on Bakelite forms, with poor insulation and no tropicalization. Many of the parts were either bought on American distress markets about 1930-32 or are very good replicas of such parts. All the tubes bear American nomenclature and



Figure 2. German type EZ 2 direction-finder receiver used in conjunction with the *FuG 10*

are identical in construction to American glass tubes. The over-all electrical design and construction of this set is about ten years old from our viewpoint.

The latest Japanese airborne radio-communication set that has been received is the model 99 type 3, removed from a type-97 light bomber which crashed September 30, 1943, in China. The components consist of a transmitter and receiver, covering 2.5-5 megacycles; dynamotor, antenna-matching unit, control unit; and primary-voltage control box. The emission is continuous wave, modulated continuous wave, or phone. The normal range is about 75 miles at 10,000 feet, a possible range of 150 miles using phone under favorable conditions and altitudes, and a range up to 300 miles using continuous wave.

The receiver uses four type 6F7 tubes. These tubes are identical with the American 6F7, except that they use an octal base and metal envelope in place of the American seven-prong base and glass envelope. Each tube, being a pentode and triode in the same envelope, serves as a dual-purpose tube. The eight stages consist of one radio-frequency stage, one mixer, one high-frequency oscillator, two intermediate frequency stages, second detection beat oscillator, automatic-volume-control stage, and audio stage. Plate voltage was measured as 250 volts.

The transmitter utilizes a crystal oscillator, modulated by a single audio modulator tube. Both tubes are type 807s. The frequency-tuning control is a combination variometer-condenser and the antenna coupling is accomplished by the use of a variometer. When modulated continuous wave or phone is used, a 50,000-ohm resistor is placed in series with the oscillator plate to prevent the tube from exceeding its maximum rating during modulation peaks. Celluloid covers are placed on the variometers and movable condensers but are not dustproof. In the receiver, all parts are clearly marked, and servicing is made easy by neat wiring and test panels.

It is recognized that the Japs are usually not original but are extremely quick to tool up and reproduce. The physical construction of model-99 type-3 set is exceedingly neat and facilitates easy servicing by clearly marked parts and test panels for measuring voltage. Wiring is neatly carried throughout and does much to dispel the idea that Japanese are capable only of copying. A number of

points of design resembling American technique have been adapted rather than copied. However, it must be remembered that American and British designs have advanced to higher frequencies and the facility of push-button tuning for both transmitters and receivers.

Generally speaking, Japanese ground signal radio equipment is similar to airborne sets. However, on the ground, wire communication and visual communications are both utilized in signaling in addition to radio.

Among the German ground signal equipment there is the German tank radio set consisting of the transmitter 10WSc and receiver UKWEe. This is an amplitude-modulated set covering a frequency range of 27.2-33.4 megacycles. The transmitter and receiver operate from separate external dynamotor power supplies. Normally the drain from a 12-volt storage battery is 7.2 amperes for the transmitter and 4.0 amperes for the receiver. Under these conditions the transmitter output into an antenna load of 40 ohms is five watts.

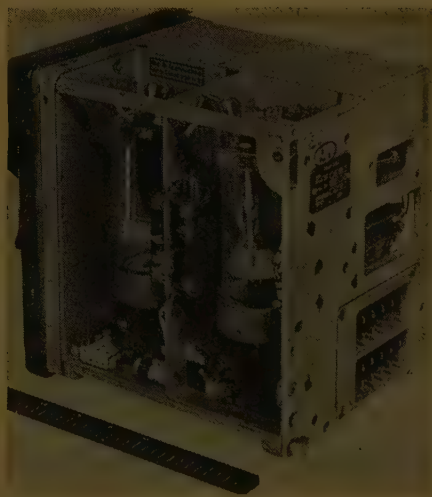
The transmitter and receiver utilize identical tuning mechanisms. A large circular dial face clearly marked in 50 divisions is used. Provision is made for setting up two preselected "flick" channels. An uncalibrated auxiliary dial is employed on the receiver to provide fine tuning. The dial of the transmitter is calibrated very accurately, and it is possible that netting may be accomplished without the use of auxiliary equipment. It is a very simple matter to set up the preset channels. Transmitter dial error does not exceed 7.5 kilocycles throughout the dial scale, and dial "flick" resettability error has been found to be less than 750 cycles per second.

The receiver is a conventional superheterodyne. The intermediate frequency is three megacycles and operates at less than signal frequency. The oscillator is self-excited and is stabilized by the use of temperature-compensating condensers. The transmitter is a self-excited oscillator with a single-tube final amplifier using an RL-12P 35 tube in each stage. The oscillator operates at one-half the output frequency. One type-RV-12P 4,000 tube is used as a grid modulator and modulated-continuous-wave oscillator.

As in the receiver, the transmitter oscillator is stabilized by the use of temperature-compensating condensers.



A. Receiver E16Z



B. Transmitter S16Z



C. Modulator BG16Z

Figure 3. Newest German air-borne radio command set FuG 16Z



Figure 4. German Notsender sea rescue radio set NS 2

Neon-tube voltage stabilizers are used in the oscillator-plate supplies of both the receiver and transmitter. During tests on battery-voltage drift the transmitter varied no more than plus or minus 250 cycles for battery voltages ranging from 10 to 14 volts. The receiver varied less than plus or minus four kilocycles for the same range of battery voltages, representing 0.013 per cent at 30 megacycles. As to temperature drift, the transmitter and receiver displayed a high degree of stability.

The transmitter stability between +30 degrees centigrade and +75 degrees centigrade is comparable to that which might be expected of a crystal-controlled transmitter. The effects of vibration were found to be negligible. This equipment when used in battle had apparently been sealed against fine sand by means of pitch inserted in the cracks between the front panels and the housing.

The German Tornister or pack set *Fuf* is the one used in greatest quantities by the communications personnel of the ground forces. The set, a transmitter-receiver combination, capable of operation on continuous wave or voice, is housed in two cases, one containing the transmitter and receiver and the other containing the power supply and remote-control unit and accessories. This equipment operates on a frequency range, as far as the transmitter goes, of from 4,500 to 6,670 kilocycles, while the receiver is capable of

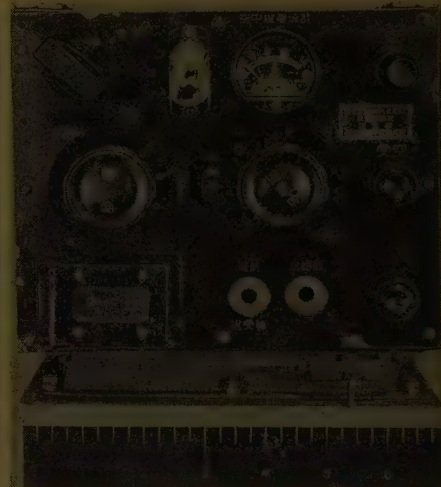
receiving a wider range of from 3,000 to 6,600 kilocycles.

The transmitter is a modulated-output power-amplifier type. The receiver is the conventional superheterodyne pack. The intermediate frequency of the receiver is 2,000 kilocycles, and the set can be calibrated quickly by the use of a glow-quartz resonator. The use of remote operation by the Germans is typical of all of their ground signal sets. It is possible, for example, by using this remote-control unit, for the officer in the remote operation to modulate the transmitter at the observer's point merely by flicking the switch. In a similar manner it is also possible by use of a bell located at the remote location, for the officer to talk back, modulating the pack set at the observer's point. Then there is a third fitting on the switch which allows the remote line to be operated as a field telephone.

The German telephone carrier unit model *TF-b2* is comparable to the Bell System's type-*H-1* carrier equipment. It provides one telephone circuit in addition to the regular voice frequency when operated on a two-wire



A. Receiver



B. Transmitter

Figure 5. Japanese air-borne radio-communication set, model 99, type 3

line. Signaling is accomplished by shifting the carrier frequency 500 cycles. Transmission is single side-band suppressed carrier; in one direction it transmits the upper side band of 11 kilocycles, and in the other direction it transmits the lower side band of 11 kilocycles. It may

be used at either end of a circuit by means of a switch selecting either terminal, *A* or *B*. The telephone channel transmitted is from 250 cycles to 2,200 cycles. The equipment operates entirely from a 12-volt battery; total drain is about two amperes. A built-in-vibrator power pack is used for plate voltages and supplies 180 volts; total plate-current drain of the set is about ten milliamperes.

The modulator used is a ring modulator, metallic-rectifier type having similar characteristics to the varistor used in this country. A 20-cycle incoming signal will operate



Figure 6. German tank radio set consisting of transmitter 10WSc and receiver UKWEc



Figure 7. German Tornister or pack transceiver, type Fuf, showing battery box (left), handset, and remote-control ringing generator

relays to produce the 500-cycle shift of the carrier and also cause the carrier to be transmitted. A guard band is used; one relay and associated circuit rejects 500 cycles, another relay and circuit rejects all voice frequencies except 500 cycles. A relay chain produces 20 cycles to send a received ring out to the other station. The range is about 16 miles when used with German field-telephone cable; this is a cable similar to American spiral four. On open-wire lines the range is approximately 125 miles. The *TF-b1* is a similar unit that operates with a carrier frequency of 5,500 cycles. The *TF-b2* and *TF-b1* can be used on the same line, giving a total of three telephone circuits. Two *TF-b2* units can be used back to back, at intermediate points, as a repeater.

The German telephone dial unit follows, generally, the conventional design of American dials produced by "independent" telephone manufacturers, and its performance seems satisfactory. The assembly of the operating mechanism, however, is not so compact, nor its operation so quiet as American-made dials. The ringer is an electromagnetic nonpolarized reed-type buzzer and weighs 1.8 ounces.

Two German field telephones, model 33 were examined in the Signal Corps laboratories and found identical with United States Army *EE-8*, except for the finish of the cases and type of instrument wire. The handset is similar to the Signal Corps type *TS-9* (used with the *EE-8*) but employs a lever-type transmitter switch. Talking tests indicate that both the German field telephones compare favorably with ours.

From all indications, the majority of the German field-wire installations use ground-return circuits. The latest German field wire is a single conductor of eight steel strands and one of copper. Evidence has been found of one strand of aluminum instead of the copper. It is covered with a bright red synthetic insulation. The tensile strength of the wire is excellent, but the handling of it is difficult.

The Japanese direction-finder and intercept receiver model 94 is a loop direction finder covering the frequency range of 100 to 2,000 kilocycles. The receiver is a tuned radio-frequency set employing three stages of radio-frequency amplification, a heterodyne detector, and two stages of audio amplification. The components and circuits employed are comparable to those used in American sets of the 1925-30 period. The loop assembly consists of a T-shaped mast and crossarm, forming a frame, upon which is wound a six-turn unshielded diamond-shaped loop approximately 16 square feet in area. The outstanding feature of the Japanese direction finder is its portability. This makes it ideal for use in jungles or other difficult terrain.

The Japanese "walkie talkie" model 66, picked up in a creek at Kiska, is a superregenerative transceiver similar to those used in the United States by the radio amateurs during the early 1930's. This set uses a type *U2-12C* dual-triode tube similar to the American type 30. Various bands of frequencies are used in the 2-megacycle to 90-megacycle range. The power requirements are 6 volts and 150 volts direct current, supplied by batteries in a separate box. In general, the layout of both parts and wiring is complex and difficult to trace or repair. The front panel is complicated by switches and dials, all of which have to be adjusted for any one frequency. In comparison with the United States "walkie talkies" and "handie talkies" using superheterodyne receivers and crystal control, the Japanese set is very difficult to operate satisfactorily under conditions of humidity and woody terrain.

The Japanese command transmitter, model 94, number 2, type *B*, is a man-pack set designed for use at Division Headquarters. This radio set is an exception to the usual Japanese run of inferior-quality equipment. It is very well constructed, and its ruggedness, simplicity, and general excellence of design are worthy of note. Considering the specific purpose for which this set was designed, it is unexcelled by any similar American equipment.

It consists of a transmitter, receiver, and gasoline-engine power-supply unit. Frequency coverage of the transmitter is from 950 to 6,675 kilocycles, and the trans-



Figure 8. German field telephone, model 1933, complete with Telefunken handset and ringing generator (left) which is identical and interchangeable with United States Signal Corps type *EE-8-A* set (center), and Japanese field telephone (right)



Figure 9. Japanese special direction-finder and intercept receiver model 94, type 7, mounted in frame support and including azimuth and shaft connecting with loop antenna on top

Figure 10. Japanese "walkietalkie"

Frequency range 2,500 to 4,500 kilocycles. Power-supply battery 1.5 to 135 volts. Comparable to SCR-194 except not ultra-high frequency



mitter power output averages about 85 watts over this range. The receiver covers from 140 to 15,000 kilocycles. It is superheterodyne type with a 100-kilocycle intermediate frequency for the range 140 to 1,050 kilocycles. For the remainder of the frequency range up to 15,000 kilocycles the intermediate frequency is 400 kilocycles. The receiver is powered by batteries, while the transmitter uses a very well-designed gasoline-engine unit. This machine delivers approximately 914 watts and weighs 103 pounds complete, which is approximately one third of the weight of our corresponding power unit, the *PE-49*. The supply to the transmitter itself is five amperes at 12 volts and 175 milliamperes at 1,300 volts.

The Japanese use ground-return circuits in their field-wire systems; the Japanese single-wire-conductor field wire employs conductor strands the same in number and material as those of standard Signal Corps field wire *W-110-B*, but with a smaller diameter. The wire had high tensile strength and low abrasion resistance. The electrical characteristics are not so good as might be anticipated from the construction. There is very little evidence of the Japanese using field switchboards, but they utilize a "party-line" system employing ground return instead.

The Japanese field telephone is contained in a metal-reinforced wooden case. The circuit is of the conventional

design with the exception of a buzzer and key arrangement that is used to send code. A spare transmitter unit is provided with each telephone for replacement purposes. The case cannot be waterproofed, because of the hinged front wall, the buzzer-key opening, and the louvers. A portable lightning arrester is provided consisting of a black rubber case, two line-binding posts, fiber-encased fuses, choke coils, metal-discharge blocks, mica insulators, and flexible ground lead. Compared with United States standards, the general mechanical construction of this set is inferior. Talking tests indicate that the Japanese field telephone does not compare favorably with the Signal Corps telephone *EE-8*.

In general, German ground components are well built and thoroughly designed. All parts are marked with terminal numbers to facilitate easy replacement. Wiring is small and neatly cabled. Dials are well machined and very accurate. Backlash is at a minimum. In all sets emphasis is placed on design for mass production.

Japanese ground parts are of rather obsolete design and in some cases very inferior to American parts. Japanese coil forms are, in general, very poor. Usually wooden or molded-mud insulation coils are used, even in equipment operating up to 90 megacycles. Jap transformers are usually unpotted, and there is no evidence of weather-proofing. Jap crystals and holders are, however, of good design. Several Jap holders examined have been very accurately molded; crystals are accurately ground.

Generally speaking, it may be said that German equipment is the best enemy equipment and Japanese equipment is probably the poorest. However, both German and Japanese equipments have points of interest to engineers, and we can and do learn from all our enemies. It is the right of American engineers to know as much as is consistent with military security about the enemy's communications equipment. This is the first complete discussion of enemy signal apparatus that has yet been made public by the Signal Corps.

Figure 11. Japanese mobile command net transmitter, 200 watts, model 94, number 2, type B, for frequency range 950 to 6,675 kilocycles, complete with power-supply gas-engine-driven generating set (left), 1,300 volts (similar to *PE-49D*)



INSTITUTE ACTIVITIES

Preliminary Arrangements for Summer Technical Meeting

Arrangements now are being made for the summer technical meeting of the AIEE to be held in St. Louis, Mo., June 26-30, 1944. Meeting headquarters will be in the Hotel Jefferson, which has ample meeting room facilities including some air conditioned rooms. The annual meeting of the Institute will be held on Monday, June 26.

Three important anniversaries will be commemorated during the meeting. The 100th anniversary of the Morse telegraph will be recognized in a special session with papers on telegraphy. The 60th anniversary of the founding of the AIEE will be celebrated, as well as the 40th anniversary of the International Electrical Congress. The first international electrical congress was held at St. Louis in 1904.

Tentative arrangements are being made to schedule 27 technical sessions and conferences. The subject matter will range throughout the entire breadth of professional interest in the electrical industry.

Those making the arrangements for the meeting are B. D. Hull, *chairman*; I. T. Monseth, *vice-chairman*; L. L. Crump, *secretary-treasurer*; F. A. Cooper, Jr., *chairman*, St. Louis Section. Subcommittee chairmen: C. B. Fall, *finance*; C. H. Kraft, *meetings and papers*; B. T. McCormick, *registration and information*; R. G. Meyerand, *hotels*; E. S. Rehagen, *hospitality*; Guy W. Thaxton, *transportation and trips*; L. F. Woolston, *publicity*.

SECTION

Lee Explains Plane-Speed Recorder to Akron Section

An electronic device, which automatically reads recording instruments and prints the readings on a chart was described by E. S. Lee (F '30) engineer in charge of the general engineering laboratory of the General Electric Company, Schenectady, N. Y., at a recent meeting of the Akron Section of AIEE. The instrument is used to measure the speed of motors used in airplane wind-tunnel tests.

The behavior of newly designed airplanes is ascertained by testing models powered with small-scale electric motors in a wind tunnel. Data about the performance of the miniature motors must be determined with great precision in order that the results may be transferred accurately to the full-sized planes, Mr. Lee said. The indications picked up by electron tubes from the motors under test cause the rotation of a tiny thyatron-controlled motor which in turn drives wheels carrying type. When the operator takes a reading, he presses a button and the type wheels print their setting at that moment. Mr. Lee added that the mechanism may be adjusted so that it gives

the equivalent of readings on a scale more than eight feet long.

STANDARDS

The following AIEE Standards may be obtained from AIEE headquarters, 33 West 39th Street, New York 18, N. Y., at the prices specified. A 50 per cent discount is allowed to AIEE members on single copies.

Modification and Supplement to AIEE Standard 45. This supplement to AIEE Standard 45, "Recommended Practice for Electrical Installations on Shipboard," is a revision issued January 1, 1944, of the first edition issued April 1, 1943. These modifications of Standard 45 are issued solely for the purpose of conserving critical materials and are to be used in conjunction with the present Standard 45. Copies are 50 cents each.

Standards for Capacitance Potential Devices and Outdoor Coupling Capacitors. This AIEE Standard 31, as approved January 27, 1944, is a revision of the proposed Standard of the same title issued in report form for trial use in December 1941. Copies are 30 cents each.

American Standard Z32.10. Graphical Symbols for Electronic Devices. This American Standard, approved this year, is a revision in part of the former American Standards Z10g3-1933 and Z10g6-1929 (AIEE numbers 17g3 and 17g6). This Standard is intended to cover the symbols for electronic devices known as electron tubes, and was developed to co-ordinate the various basic symbols for those devices. Copies are 20 cents each.

American Standard C19. Industrial Control Apparatus. This is a revision of the 1928 edition of the American Standard C19 (former AIEE Standard 15). It covers definitions; classification of controllers, switches, and resistors; kinds of protection, enclosure for protection of persons and apparatus; duty and service; ratings; temperature limitations and limitations other than heating; temperatures, and dielectric tests. Copies are 50 cents each.

Bushing Standard Approved as American Standard

The American Standards Association has approved, as an American Standard, the Standards for Apparatus Bushings and Test Code for Apparatus Bushings (number 21), which was developed by the AIEE.

The standards for apparatus bushings specifically cover outdoor bushings for large apparatus; cover-type bushings for small apparatus; and indoor bushings for all types of apparatus except dry-type instrument transformers, air-blast transformers, dry-type regulators, circuit breakers rated below 5,000 volts, and nonoiltight oil circuit breakers rated 50,000 kva or less. The main specification includes requirements for service conditions, definitions, ratings, heating, dielectric tests, and nameplate markings, and has a table of standard test voltages for apparatus bushings. The standards are not intended to apply to wall bushings, cable potheads, nor insulators for back-connected disconnecting switches, although many of the principles may be applicable.

The Test Code for Apparatus Bushings, which is published with the standards as an appendix, pertains to tests on apparatus bushings apart from those tests on the assembled apparatus. There is a classification of bushings tests, test procedure, adjustment of conditions for wet test, standard test conditions, correction factors, and routine and design tests.

The Standard is now available and may be obtained for 40 cents a copy from the ASA, 29 West 39th St., New York 18, N. Y. Members of the AIEE are allowed a 50 per cent discount.

ABSTRACTS

TECHNICAL PAPERS previewed in this section will be presented at the AIEE North Eastern District meeting, Boston, Mass., April 19-20, 1944, and are expected to be ready for distribution within the current month. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk.

Mail orders will be filled
AS PAMPHLETS BECOME AVAILABLE

Air Transportation

44-72—A Unit for Balancing the Voltages of Three-Phase Aircraft Inverters Supplying Large Single-Phase Loads; *Sydney Wimpie (A '42).* 15 cents. Increased electrification of military aircraft has necessitated putting large single-phase loads on three-phase inverters without unbalancing the inverter's terminal voltages. A balancer unit that makes a single-phase load appear as a balanced three-phase load to the power supply is described. Extensive test data are furnished and various advantages and limitations of the unit are discussed. The basic vector diagram plus certain design considerations are also treated.

44-81—A-C and D-C Short-Circuit Tests on Aircraft Cable; *J. C. Cunningham (A '42), W. M. Davidson (A '42).* 25 cents. Short circuits between aircraft cables and between

cable and metal structure were investigated in the laboratory to determine (1) reasons for the apparent freedom from sustained faults in present 28.5-volt d-c systems despite heavy gunfire damage, and (2) whether faults will burn clear as readily on proposed 120-volt d-c and 208/120-volt 400-cycle systems. The tests show (1) that freedom from sustained faults on 28.5-volt systems can be attributed mainly to spreading of wire strands by gunfire and the high level of short-circuit current at most locations, and (2) that ability to burn clear would not be materially different at the higher voltages if as much short-circuit current were available. The use of protective devices to isolate faulted cables will reduce fire hazard if short-circuit current is less than 2,000 amperes for number 8 cable, 1,000 amperes for number 14 cable, and 300 amperes for number 20 cable. For 400-cycle systems, protective devices usually will be required to clear faults with minimum generation in time to prevent loss of synchronism or stalling of motors.

44-82—Damping Cylinders for Aircraft Gyroscopes; *F. R. Sias, J. H. Wright (M'43). 20 cents.* Air-damping cylinders have been applied successfully to the erecting system of a gyroscope horizon instrument for aircraft. In so doing, a degree of damping is obtained which would not be possible by other means within the same limitations of space and weight. It is shown that these cylinders do not act as pure damping agents, but introduce an elastic component of force which varies in relative magnitude with the amount of compression of the confined air and its absolute pressure. By a method employing an electrical analogy, the factors which control the ultimate damping effect are analyzed, and it is shown that cylinder design must follow certain dimensional requirements dictated by the dynamics of the whole oscillating system. These considerations determine the minimum size of cylinder which can be used in a given application and also the piston clearance which gives maximum damping effect.

44-83—Aid to Quality Control in the Manufacture of Aircraft Generators; *F. M. Potter. 15 cents.* Aircraft generators are designed for high output, low weight, small size, and wide speed range. These limitations require designs which do not permit normal allowances for material and manufacturing variations. Small variations in the material and manufacturing processes result in wider variations in output characteristics than in conventional machines. It is the purpose of this paper to discuss certain of these variations and their effect on the output characteristics of the machine and to illustrate means of checking and controlling these factors.

44-84—Blast-Tube Cooling for Aircraft Generators; *C. G. Veinott (M'34). 20 cents.* Established principles of hydraulics are used to develop and explain fundamentals of blast-tube cooling. It is shown that the pressure-volume curves of a blast tube can be determined by flight tests, and that the pressure-volume of a generator can be determined in the laboratory. From the two pressure-volume curves, the air flow through the generator in flight can be predicted without an actual flight test on the

generator. This procedure would save many flight tests, if pressure-volume curves of various blast tubes were available. It is shown that the pressure-volume curve of a blast tube can be determined by open-end and closed-end readings on the blast tube and the complete curve expressed in terms of two constants readily determined from these readings. Once values of the constants are established, air-flow calculations become as simple as the application of Ohm's law. The theory also covers generators with an internal fan. A plea is made for accurate blast-tube data and for better specifications on blast cooling. A suggested form of blast-tube specification is given.

Electrical Machinery

44-75—A Graphical Analysis of the Voltage and Current Wave Forms of Controlled-Rectifier Circuits; *P. T. Chin (A'41), E. E. Moyer. 30 cents.* Controlled rectifiers employing gaseous discharge tubes are used more and more frequently in the industrial field because of the ease of controlling the output voltage and the high conversion efficiency. The voltage and current wave forms at the different parts of controlled-rectifier circuits are often nonsinusoidal and discontinuous due to the one-way valve action of the rectifying elements. This paper presents a graphical method of constructing the voltage and current wave forms based on a few well-known fundamental principles of electrical engineering. The method is presented step by step and a few typical examples are shown to illustrate its validity.

44-86—Behavior Factors of Rectifier-Driven D-C Motors; *Victor Siegfried (M'38). 15 cents.* This paper proposes to analyze the behavior of d-c motors when subjected to pulsating direct current from rectifier sources. It is felt that this phase of the application of electronic drives has been given insufficient consideration, particularly in regard to (1) heating value of the current waves, (2) voltage stresses upon the insulation and commutator resulting from the high peak values involved, and (3) torque pulsations and noise resulting from this type of wave form. Experimental and theoretical approaches are made to illustrate the possible ratios of effective heating value to the average value of typical wave shapes encountered in electronically driven motors. The degree to which these values approach each other varies with the load on the machine and also with the number of tubes used in the rectification. The conclusion is reached that this problem is most acute in machines of small rating where the mechanical inertia is low, and tube capacities permit use of but one or two tubes for economy of materials. This very condition aggravates both the heating and the vibration problems, and may require overmotoring, the application to allow for thermal capacity. Vibrations will also show up in work on such machines as grinders and in chatter marks on the finished surfaces. With many tubes (phases) in the rectifier the current output approaches conventional continuous-current practice, and standard-design motors may be used. The over-all conclusion to be drawn is that factors not at first apparent must be considered

in the application of rectifier drives to any given motor or load and no over-all design factor may be presumed to apply to all cases.

44-87—Design of Variac Transformers; *Eduard Karplus (M'44). 15 cents.* The paper describes a new continuously adjustable variable-ratio autotransformer for regulation of line voltage from zero to above line voltage. Operation of the new transformer depends on the application of a carbon-composition contact directly on the turns of the transformer winding. In sliding over the winding, the contact taps off any desired number of turns. The resistance of the contact prevents excessive heating when adjacent turns are short-circuited. The winding has to be applied in a single layer and the core of the transformer is made toroidal in shape to allow compact design. The problem of contact design for minimum losses and the characteristic of a single-layer transformer winding are discussed in detail.

Electronics

44-78—Development of Excitron-Type Rectifier; *H. Winograd (M'39). 30 cents.* This paper describes the design and development of the excitron-type rectifier which is the latest addition to the family of mercury-pool-type power rectifiers. The excitron is a single-anode rectifier with a continuous excitation arc maintained at the cathode when in operation. The experimental test method used in the development of the excitron is described. This method is based on the measurement of the inverse (ion) current to the anode which current results from the residual ionization at the conclusion of the forward firing period. The relationship between the inverse current and arc-backs is discussed and test results are given on a number of experimental excitron designs.

44-79—ACO—The Application of Broad-Band Carrier Systems to Telephone Cables; *J. P. Thurber. 20 cents.* In planning for additional long-distance facilities between Boston, Mass., and Portland, Me., the important considerations which led to the choice of the route finally followed and the different types of facilities which might be placed on this route are outlined. The reasons for the selection of broad-band-cable carrier systems working in two 19-gauge cables are given and the laying of these cables by plowing them into the ground directly from the reel is described briefly. The main points which had to be considered before arriving at the final location of the repeater stations are reviewed and the precautions which were necessary to keep the cross-talk in the cable plant at a minimum are covered. A brief description of the equipment and operation of the systems is given besides.

Power Generation

44-71—Vibration Protection for Rotating Machinery; *R. L. Webb (M'35), C. S. Murray (A'34). 15 cents.* Vibration protection becomes desirable for rotating machinery when it is operated with certain defects. Electric generators may be operated with a

single ground on the rotating-field circuit without harm but the potential hazards of a second ground at another point on the same circuit are so great that the need for protective equipment for automatic disconnection of the generator is evident. Double grounds on a rotating-field circuit may short-circuit a large part of the winding, unbalance the magnetic field, and set up vibrations of such serious magnitudes that the machine may be wrecked. A method for obtaining satisfactory vibration protection for rotating machines has been developed. It uses equipment most of which is already on hand or readily available to most companies operating important machinery. The only additional construction required is an electronic amplifier. The equipment, its operating characteristics, wiring, and performance are described in this paper. The protective equipment described has been in service on one machine since the latter part of 1942, furnishing entirely satisfactory service. Another machine was protected in a similar manner for about three months until it was found convenient to rewind the field.

44-85—Prevention of Rotor-Winding Deformation on Turbogenerators; *J. G. Noest (M'36). 25 cents.* This paper discusses the phenomenon of rotor-winding deformation, which has been the cause of a number of failures in large turbogenerators. Rotor-winding deformation is shown to be the result of the combined action of centrifugal force and temperature change. Most of the deformation is caused in starting the generator, when the rotor winding is heated from ambient to operating temperature, and restrained from axial expansion by the centrifugal force. Preheating of the rotor winding by means of current in the winding at low generator speed is shown to be effective in reducing deformation as it permits the rotor conductors to expand to a length corresponding to a time-weighted average operating temperature, without the restraint caused by centrifugal force. The rotor winding thus reaches rated generator speed practically free from mechanical stress, and subsequent temperature changes produce only small values of stress in the conductor material.

Power Transmission and Distribution

44-73-ACO—Reliability of Compressed-Gas Insulation; *J. D. Cobine (M'41), E. C. Easton (M'44). 15 cents.* Measurements were made to determine the length of time during which compressed nitrogen can withstand a nearly rectangular voltage surge. The voltage was applied between spheres in gas under pressure variable from one half to six atmospheres. For each set of measurements the maximum value of the applied voltage was set at a constant percentage above the static breakdown voltage. For a fixed percentage of overvoltage the most probable time lag (before the breakdown of the gas) dropped rather sharply from large values of several thousand microseconds to values of five to ten microseconds as the pressure was increased beyond a certain critical value. Thus, whereas the static breakdown voltage increases with an increase of gas pressure, the probability that the gas will break down

under the stress of short voltage surges is much greater at high pressure than at lower pressures.

44-74-ACO—110-Kv Tie Line Uses Progressive Design; *E. A. Church (A'29), E. G. Stebbins. 15 cents.* An "H" frame wood-pole line completed by the Boston Edison Company in December 1941 was designed to have the highest impulse strength consistent with reasonable cost. In this line the wood crossarms and the pole tops are used as insulation in series with the insulators. For d-c and a-c voltages of low frequency, the wood has very little value as an insulator. However, for impulse voltages of very short duration, wood has an impulse strength of about 87 kv per foot, and can be used to advantage in series with the insulator string to raise the impulse strength of the line. The line is equipped with two steel overhead ground wires, mounted on the pole tops, seven feet above the crossarms, and sagged to give from 13 to 20 feet of clearance at midspan depending on the length of span which varies from 300 to 500 feet. These ground wires are connected to a continuous steel counterpoise by means of leads connected to the ground wires eight feet from the poles and fastened to the poles seven feet below the crossarms to obtain 13 feet of wood between the insulator string and ground. No outages have been recorded for this line during two lightning seasons.

44-76-ACO—Conversion of Montaup Electric System From 66 Kv to 110 Kv; *W. B. Carnie (A'39). 15 cents.* This paper describes the conversion of a transmission system from 66 kv delta to 110 kv wye in one week end without interrupting service to the customers. To provide for increased loads additional transformer and 110-kv tie line capacity as well as retention of low-voltage ties were included in the change. Preparation included an a-c calculating-board study of voltage and load conditions.

44-77-ACO—Improving the Performance of 110-Kv Lines; *D. H. Hatheway, A. B. Jones. 15 cents.* This paper reviews changes made in an existing two-circuit steel-tower transmission tie line (part of the Edgar-Walpole-Millbury tie) with a record of unsatisfactory operating performance, to increase its reliability to the point at which it now constitutes a dependable intersystem tie. The relaying system was improved in several respects. Expulsion protector tubes were installed at each conductor on each tower to improve performance with respect to lightning. High-speed trip coils and arc-quenching contacts were installed in the circuit breakers to decrease circuit interruption. These changes have effected the desired improvement. Because of the increasing importance of the line for power interchange between two large systems, the transformer capacity at the Edgar station has been increased nearly 100 per cent and carrier-current relaying and automatic reclosing of the line's oil circuit breakers are about to be installed to reduce the duration of circuit outages.

44-80—Measured Electrical Constants of 270-Mile 154-Kv Transmission Line; *C. A. Streifus (M'44), C. S. Roadhouse, R. B. Gow*

Future AIEE Meetings

North Eastern District Meeting
Boston, Mass., April 19-20, 1944

Summer Technical Meeting
St. Louis, Mo., June 26-30, 1944

Pacific Coast Technical Meeting
Los Angeles, Calif., Aug. 29-Sept. 1, 1944

(A'35). 25 cents. Electrical constants were measured by applying 2,400/4,160-volt potential to appropriately connected conductors at one terminal. Indicating instruments furnished data for obtaining open- and short-circuit impedances of positive-phase, zero-phase, and one-conductor-and-ground networks. These impedances were converted to fundamental ABCD constants, and then to unit resistance, inductive reactance, and capacitive susceptance, and to characteristic or surge impedance. Theoretical constants computed from line dimensions are compared with measured values. Results indicate good agreement between measured and computed positive-phase constants. Measured and computed capacitive susceptances agree closely for the zero-phase and one-conductor-and-ground networks. Greatest difference occurs between measured and computed unit resistances and inductive reactances in these two networks, due possibly to the difficulty of including in computations all effects varying with current density, of resistance and reactance of shield wires; indefinite value of resistivity in earth return path; and variations in conductor and shield wire configuration.

PERSONAL

I. B. Stiefel (A'18) formerly manager of industrial relations, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been appointed assistant to the vice-president in charge of industrial relations. Mr. Stiefel has been with the Westinghouse company since 1912 when he entered its graduate student course. He has been assistant superintendent of coils and insulation, assistant superintendent of the motor division, superintendent of mill and foundry, and manager of the feeder division number one. Since 1937 he has been manager of industrial relations. **F. R. Benedict (A'40)** formerly manager of the New England district engineering and service department of the Westinghouse company has been appointed manager of product performance analysis. Associated with the Westinghouse company since 1928, Mr. Benedict was manager of the company's Trafford laboratories and impulse laboratory from 1936 to 1938. He was appointed liaison engineer on the chief engineer's staff in 1938, consulting and application engineer in the district engineering and service department in 1940, and manager of that department for the New England area in 1941. **H. H. Chapman (A'36, M'42)** formerly manager of the Minneapolis (Minn.) office of the Westinghouse company, has been made manager of the company's

transportation department. Mr. Chapman joined the company in 1920 and has been manager of the Minneapolis office since 1936. **H. L. Rawlins** (A '30, M '41) formerly section engineer in the Westinghouse company has been named manager of the protective devices engineering department. Mr. Rawlins, who holds the degree of master of science from Ohio State University, has been associated with the company since 1928 and has been section engineer since 1936. **A. W. Hill** (A '38, M '41) formerly of the switchgear engineering department of the Westinghouse company has been appointed manager of power circuit breaker engineering. Mr. Hill has been with the company since 1920 and in the switchgear division since 1925.

A. M. Dudley (A '03, F '13) engineering representative, patent department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., retired recently. Born in Cincinnati, Ohio, in 1877, Mr. Dudley received from the University of Michigan the degrees of bachelor of science in 1902 and electrical engineer in 1931, and from the University of Pittsburgh the master of science degree in 1933. He was honored by the University of Michigan with the degree of doctor of engineering in 1939. Mr. Dudley joined the Westinghouse company in 1904 as a control engineer and later became engineering supervisor of development, manager of development engineering, marine application engineer, and finally engineering adviser in the patent department. For many years he was engaged in recruiting young engineering graduates for the Westinghouse graduate student course. He is the author of "Connecting Induction Motors," "Induction Motor Practice," a correspondence school course in electricity, a Westinghouse extension school course, and the article on electric motors in the current edition of the Encyclopedia Britannica.

L. A. Howland (A '00, F '13) vice-president and general manager, Queens Borough Gas and Electric Company, Far Rockaway, N. Y., has retired. Mr. Howland entered the employ of the Stanley Electric and Manufacturing Company, Pittsfield, Mass., in 1895 doing testing and construction work. Subsequently he had charge of construction and testing for the Royal Electric Company and for the Canadian General Electric Company, Montreal, Que. With the Newfoundland Light and Power Company, St. Johns, from 1902 to 1906 he was engaged in electric light and power and street railway management, and in 1906 was appointed manager of the Nassau Light and Power Company. Joining the Queens Borough company in 1909 as general superintendent he was elected vice-president in 1926. In 1927 he was appointed vice-president and general manager and in 1933 was made a director.

F. C. Stockwell (A '12, M '27) professor of electrical engineering and dean of the graduate school, Stevens Institute of Technology, Hoboken, N. J., has resigned as dean of the graduate school. Professor Stockwell has been a member of the faculty since 1907 and has been dean of the graduate school since 1939. **W. L. Sullivan** (A '34, M '42)

formerly assistant professor of electrical engineering, has been appointed associate professor and director of the graduate school. Professor Sullivan, who is a graduate of Massachusetts Institute of Technology, joined the faculty as instructor in 1934. He was appointed assistant professor in 1936 and assistant to the dean of the graduate school in 1939. **L. A. Hazeltine** (F '35) professor of physical mathematics, has resigned to devote his attention to research work. He served on the faculty from 1907 to 1925 and recently since 1933.

E. E. Minor, Jr. (A '35, M '41) consulting engineer and research and development engineer, Glenn L. Martin Company, Baltimore, Md., has been appointed vice-president and head of the manufacturing and development division of All American Aviation, Inc., Wilmington, Del. Born in 1907, he holds the degrees of bachelor of engineering (1930) and doctor of engineering (1934). He conducted an investigation of space charge in liquid dielectrics from 1931 to 1934. In 1935 and 1936 he worked on job analysis for the United States Department of Labor, Washington, D. C., and in 1936 joined the Glenn Martin company as staff electrical engineer, later becoming research and development engineer. Doctor Minor was first chairman of the AIEE committee on air transportation in 1940.

L. B. Fuller (A '03) formerly chief engineer, Utah Power and Light Company, Salt Lake City, has become engineering consultant for the company. Before joining the Utah Power and Light Company in 1913, Mr. Fuller superintended electrical construction in Utah and Idaho for the Telluride Power Company and the Beaver River Power Company. He was employed by the Utah Power Company first as construction superintendent on various hydroelectric stations and from 1919 to 1927 was employed on construction executed by the Phoenix Utility Company for the Utah Power company. In 1927 he was appointed assistant superintendent of power by the Utah Power company, and in 1929 superintendent of power. Since 1937 he has been chief engineer of the company.

Maurice Holland (A '23, M '30) industrial research adviser, New York, N. Y., has been appointed industrial research adviser to the Armour Research Foundation, Chicago, Ill. Mr. Holland was director of the division of engineering and industrial research of the National Research Council from 1923 to 1943. He served as director of the mission on industrial exploration to South America in 1941 conducted under the auspices of the Co-ordinator of Inter-American Affairs and the National Research Council. He was a delegate to the First World Power Conference in London, England, in 1924 and to a number of other international meetings.

R. C. Griffith (A '35) director of research, Heald Machine Company, Worcester, Mass., is not the R. C. Griffith recently appointed manager of engineering and research by the Denison Engineering Company, Columbus, Ohio, as was reported in the December 1943 issue of *Electrical Engineering*. The latter is not an AIEE member.

OBITUARY

Thomas Mayo Roberts (A '02, M '12) retired associate electrical engineer, procurement division, public works, mechanical engineering section, Treasury Department, Washington, D. C., died January 10, 1944. Mr. Roberts, who was born January 22, 1867, in The Dalles, Oreg., was graduated from the University of Oregon in 1893 and from Massachusetts Institute of Technology in 1898. He remained as instructor at the University of Oregon, Eugene in 1893. During 1898 and 1899 he was employed variously as assistant in construction and installation for the Boston (Mass.) Electric Light Company in street surveying and construction for the Edison Electric Illuminating Company, Boston; and as inspector for the United States Corps of Engineers, Portland, Me. He returned to the Edison Illuminating Company in 1900 as assistant in design and equipment work and in 1901 was employed as draftsman by the New England Structural Company, Boston. In 1902 he joined the General Electric Company and remained in the company's district office at Boston until 1912. At different times during this period he had charge of drafting and designing and construction, wiring, and installation estimates. In 1913 he became professor of electrical engineering at Delaware College, Newark, and engineer for the Edison Storage Battery Company, Orange, N. J. In 1914 he was made assistant electrical engineer with the Interborough Rapid Transit Company, New York, N. Y. In 1917 he entered the Bureau of Yards and Docks, Navy Department, Washington, D. C., and except for a period in 1919 with the Bureau of Standards in Washington, remained with the Navy Department as electrical engineer until 1925. In 1926 he was made associate engineer in the supervising architect office, mechanical engineering division, Treasury Department, Washington, and in 1933 was transferred to the procurement division of the Treasury Department. He retired in 1937.

Frederick Dwight Nims (A '07, F '12) operating consultant and evaluation engineer, South Carolina Public Service Authority, Charleston, died March 2, 1944. Mr. Nims, who was born March 7, 1877, in Muskegon, Mich., commenced his career with the Muskegon Electric Light Company and the Muskegon Railway Company by which he was employed from 1894 to 1902 in various electrical positions and finally as superintendent. He was employed by the Utah Light and Railway Company, Salt Lake City, from 1902 to 1905 as division operating engineer, and in 1905 he joined the Mexico Light and Power Company, Mexico City, D. F., as chief operating engineer. From 1910 to 1914 he was associated with the Western Canada Power Company, Vancouver, B. C., as electrical engineer and general superintendent. He was assistant general manager and engineer for the Olympic Power Company, Port Angeles, Wash., from 1914 to 1916, becoming consulting engineer of the Olympic company in the latter year as well as general manager for the Washington Coast Utilities, Arlington. In 1917 he added the vice-presidency of the Washington Coast Utilities to his

Julius. He was director of Parsons, Todd and Company, Boston, Mass., from 1924 to 1930. In 1925 he was president of the New Hampshire Power Company, Boston, and in 1926 was appointed receiver for the Horiconia Power Company, Rutland, Vt. He returned to Mexico as division manager of the Central Mexico Light and Power Company, Irapuato, Guan., in 1930 and remained there until 1938 when he was appointed senior engineer with the Public Works Administration, Washington, D. C. He had been with the South Carolina Public Service Authority since 1940. Mr. Nims served on the AIEE Sections committee for 1914-15 and on the committee on transmission and distribution for 1914-16.

Christian Julius Larsen (A '14, F '29) transmission engineer, Automatic Electric Company, Chicago, Ill., died February 7, 1944. Mr. Larsen was born in Copenhagen, Denmark, July 13, 1876, and received the degree of bachelor of science in engineering from the Lewis Institute of Science and Technology. In 1926 he was awarded the degree of doctor of science by Kansas City University. From 1909 to 1912 he was superintendent of equipment for the American Union Telephone Company, Harrisburg, Pa., and in 1912 when the Consolidated Telephone Company separated from the American Union, he became chief engineer for the Consolidated company. In 1915 he joined the Kansas City (Mo.) Home Telephone Company, serving as transmission engineer and superintendent of equipment and maintenance until 1919. In 1919 the Kansas City company merged with the Southwestern Bell Telephone Company and Mr. Larsen became building and equipment engineer for the combined companies. In 1925 he went abroad to make a study of automatic telephone systems in Belgium, Germany, and Sweden. Returning from Europe he was assigned in 1926 to a study of the telephone potentialities of South America. Later he supervised the automatic conversion of the telephone system in Caracas, Venezuela, and served as construction engineer in Barranquilla, Columbia. In 1929 he was appointed consulting engineer to the Associated Telephone and Telegraph Company, National Telephone and Telegraph Corporation, American Electric Company, Inc., and the Automatic Electric Company, Inc. Since 1931 he had been consultant on transmission problems to the Automatic Electric Company. Mr. Larsen served on the AIEE committee on communication from 1931 to 1935 and was a life member of the Telephone Pioneers of America.

George Barnett Smith (A '12, M '13) operating superintendent, eastern Ontario system, Hydro-Electric Power Commission of Ontario, Belleville, died December 10, 1943. Born August 18, 1876, in Wolverhampton, Staffordshire, England, Mr. Smith attended McGill University. In 1901 he entered the test department of the Royal Electric Company, Montreal, Que., and later that year the test department of the Lachine Rapids Hydraulic Land and Power Company, Montreal. From 1903 to 1909 he was associated with the Montreal Light, Heat and Power Company, in the test and

meter department, the construction department, and the operating department, and was finally placed in charge of the construction department. In 1909 he joined Smith, Kerry and Chace, Consulting Engineers, Toronto, Ont., and in 1910 the Electric Power Company, Belleville, Ont., as general superintendent of the electrical department. Since 1917 he had been connected with the Hydro-Electric Power Commission of Ontario, Belleville, becoming district superintendent in 1922 and superintendent of the central Ontario system in 1925. He was made district operating superintendent in 1929 and superintendent of the eastern Ontario system in 1930. In 1937 he became operating superintendent.

William J. Davis, Jr. (A '95, M '12) retired consulting engineer, General Electric Company, Schenectady, N. Y., died February 18, 1944. Mr. Davis was born May 13, 1868, in Louisville, Ky., and was graduated from Rose Polytechnic Institute in 1892. He entered the employ of the General Electric Company, Lynn, Mass., in 1892 and was later transferred to Schenectady. He was engaged in testing, design, and construction until 1896 in which year he entered the railway engineering department. While in that department he did special engineering work in connection with the Detroit River Tunnel electrification and the electrification of the New York Central, and the West Jersey and Seashore, railway systems. He introduced forced ventilation for railway motors and made a pioneer study of train resistance. He was associated for a time with C. P. Steinmetz. From 1908 to 1921 he served as engineer in San Francisco, Calif., for the Pacific Coast district. For a part of this time he was chief engineer of the Mexican Northern Power Company. In 1921 he returned to the railway engineering department at Schenectady and when that department became the transportation engineering department in 1929 he was named consulting engineer. Mr. Davis retired in 1930.

Fred L. Hunt (A '05, F '17) vice-president in charge of operations, Western Massachusetts Companies, Greenfield, died February 8, 1944. Mr. Hunt, who was born in Delta, Iowa, August 4, 1879, received the degree of bachelor of science in electrical engineering from the University of Nebraska in 1902. He was employed in the testing department of the General Electric Company, Schenectady, N. Y., from 1902 to 1905 and in the latter year was transferred to the company's Boston, Mass., office as trouble man, later becoming assistant district engineer. In 1913 he was made chief engineer of the Turner Falls Power and Electric Company, Greenfield, and allied companies and was simultaneously general manager of the Connecticut River Conservation Company. In 1927 he was appointed director of economics and engineering of the Western Massachusetts Companies and in 1937 was elected vice-president. Mr. Hunt was a member of the following AIEE committees: protective devices, 1914-16, 1919-24, 1927-29; Standards, 1923-24, 1927-32; meetings and papers, 1926-28. He was the author of several technical papers and president of the Engineering Society of

Western Massachusetts. Mr. Hunt also served on several technical committees of the National Electric Light Association.

Edward Hutchkiss Everit (A '02, F '12) retired assistant to the general manager of the Southern New England Telephone Company, New Haven, Conn., died October 5, 1943. He was born August 5, 1870, in New Haven and attended Columbia University. Mr. Everit's entire career, which commenced when in 1889 he entered the equipment maintenance department of the Southern New England company, was spent in the field of communication engineering. He became superintendent of equipment in 1897, engineer in 1903, and chief engineer in 1910. He was appointed assistant to the general manager in 1927 and retired in 1931. Active in Institute affairs, he was chairman of the Connecticut Section from 1922 to 1924, a member of the committee on communications from 1925 to 1930, and a member of the board of examiners from 1922 to 1930 and chairman from 1927 to 1930. He also was a member of the American Society for the Advancement of Science, the American and Connecticut Forestry Associations, the Connecticut Society of Civil Engineers, the New York Electrical Society, the Society for the Promotion of Engineering Education, and the Telephone Pioneers of America.

Newton Stout Taylor (A '14, M '26) manager of switchgear order service department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., died February 21, 1944. Born in Lancaster, Ky., November 11, 1888, Mr. Taylor was graduated from the University of Kentucky in 1909. He entered the apprenticeship course of the Westinghouse company in 1909 and in 1911 was made switchboard specialist in the company's Denver, Colo., office. Returning to East Pittsburgh in 1915 he continued as switchboard specialist until 1920. In 1918 he was responsible for all work with the government in connection with battleships, navy yards, and ordnance plants. He was made acting manager of the switchboard section in 1920 and manager in 1925. In 1933 he was appointed manager of switchgear apparatus and in 1939 supervisor of the switchgear order service. Since 1940 he had been manager of the switchgear order service. Mr. Taylor was awarded the Westinghouse order of merit for his outstanding work in speeding delivery of equipment to the United States Navy and war industries.

William Beckett (M '26) design engineer, Georgia Power Company, Atlanta, died December 11, 1943. Born August 26, 1886, in Charleston, S. C., Mr. Beckett was graduated from Clemson College with the degree of bachelor of science in electrical engineering in 1906. During 1906 and 1907 he was employed in the testing department of the General Electric Company, Schenectady, N. Y. He entered the drafting department of the Public Service Electric Company, Newark, N. J., and in 1911 was transferred to the construction department as foreman on installation of substation equipment. From 1913 to 1917 he was general foreman of construction for the Carolina

Power and Light Company, Raleigh, N. C. In 1917 he joined the Georgia Railway and Power Company, which later became the Georgia Power Company, as draftsman and in 1918 became chief draftsman. From 1919 to 1922 he worked for Lockwood, Greene and Company, Atlanta, as designer. He returned to the Georgia Power Company in 1922 as design engineer and had been associated with that company since.

Ford DeCamp Thompson (A'07) retired supplies inspection superintendent, Western Electric Company, Inc., died February 3, 1944. He was born March 1, 1878, in Detroit, Mich., and first joined the Western Electric Company, New York, N. Y., in 1896. In 1898 and 1899 during the Spanish-American War he served in the Signal Corps of the United States Army. Returning to the Western Electric Company in 1899 he was placed in charge of inspecting and testing of manufactured apparatus. In 1904 he entered the engineering department to work on general apparatus inspection and in 1906 inspection of supplies for the telephone companies was added to his duties. During the next decade he helped organize repair shops and standardize repair methods and engineering inspection throughout the American Bell System. In 1919 he was named supplies inspection superintendent and in 1943 he retired.

Elmer Ellsworth Boyer (A'95, F'12) retired engineer, General Electric Company, Lynn, Mass., died February 9, 1944. He was born July 23, 1861, in Sunbury, Pa., and attended Hobart College and Lehigh University. From 1880 to 1885 he worked in the machine shops of the Pennsylvania Railroad, Sunbury, and in 1885 entered the testing department of the Thomson-Houston Company, Lynn, Mass. About 1900 he became foreman of the testing department of the General Electric Company at Lynn. In 1911 he was transferred to West Lynn, Mass., as electrical superintendent and remained in that position until 1922 when he was appointed head of the industrial service department. He retired in 1930. He was associated with such electrical pioneers as Elihu Thomson, E. W. Rice, Jr., and C. P. Steinmetz.

Charles Paul Rhine (A'18) division maintenance engineer, San Joaquin power division, Pacific Gas and Electric Company, Fresno, Calif., died January 17, 1944. Mr. Rhine was born in New Castle, Ind., November 9, 1883, and was graduated from Purdue University in 1909. He commenced his career as electrical draftsman in the signal department of the Southern Pacific Company, San Francisco, Calif., in 1909. In 1918 he joined the San Joaquin Light and Power Corporation, Fresno. He was named construction engineer in 1920, mechanical engineer in 1924, and electrical engineer in 1927. After a year as resident engineer in the San Francisco steam plant of the Great Western Power Company in 1928 he returned to the San Joaquin Corporation and had been with the San Joaquin division of the Pacific Gas and Electric Company since 1940. He was a member of the Pacific Coast Electrical Association.

Harry Molyneux King (M'21) operating superintendent, Ontario Power Plant, Hydro-Electric Power Commission of Ontario, Niagara Falls, died December 6, 1943. Mr. King was born September 12, 1877, in Brooklyn, N. Y. He commenced his career as a journeyman for an electrical contractor in Providence, R. I., and in 1903 was engaged by the Narragansett Electric Lighting Company, Providence, for substation and other construction. From 1906 to 1910 he erected apparatus for the Westinghouse Electric and Manufacturing Company, Buffalo, N. Y. He joined the Ontario Power Company, Niagara Falls, as electrical supervisor in 1910 and became operating superintendent in 1923. When the company was taken over by the Hydro-Electric Power Commission of Ontario in 1924, he continued in that position.

Weldon O. Hampton (M'41) chief design engineer, Delta-Star Electric Company, Chicago, Ill., died February 9, 1944. Mr. Hampton, who was born June 21, 1902, in Fort Smith, Ark., commenced his career in the machine shop of the Victor Electric Corporation, Chicago, in 1917. From 1918 to 1922 he worked as draftsman for the Automatic Electric Company, Chicago, and in 1922 joined the Delta-Star company as engineering draftsman. In 1926 he was made field engineer and head of standardization and in 1929 became head of the patent department. He was appointed assistant to the chief engineer in 1933, assistant chief engineer in 1937, and chief design engineer in 1941.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners at its meeting on March 16, 1944, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Crittenden, E. C., chief, electrical division and assistant director, National Bureau of Standards, Washington, D. C.
Deakin, Gerald, vice-president & general technical director, I. T. & T. and Int'l. Standard Elec. Corp., New York.
DeLanty, B. F., general manager & electrical engr., Light and Power Dept., City of Pasadena, Calif.
Hooven, M. D., elec. engr., Public Service Electric & Gas Co., Newark, N. J.
Lovell, C. M., vice-president & chief engr., Moloney Electric Co., St. Louis, Mo.
Mullen, J. J., president, Moloney Electric Co., St. Louis, Mo.
Stevens, F. J., vice-president, Engg., American Lava Corp., Chattanooga, Tenn.
Ware, J. S., general supt. of distribution, Public Service Elec. & Gas Co., Newark, N. J.

8 to grade of Fellow

To Grade of Member

Aster, A. K., engr., Westinghouse Electric Elevator Co., Jersey City, N. J.
Bailey, R. E., senior elec. engr., Tennessee Eastman Corp., Oak Ridge, Tenn.
Ballard, B. G., head of elec. engg. section, National Research Council of Canada, Ottawa, Canada.
Behrens, W. J., starting engr., S.G., Commonwealth Edison Co., Chicago, Ill.
Dandeno, L. G., supt., Thunder Bay System, Hydro-electric Power Comm., Cameron Falls, Ont., Canada.
Darrah, M. D., chief elec. engr., The Austin Co., Dallas, Texas.
d'Enis, F. B., R.N.V.R., S.A.V.S., South Africa House, London, England.
Denison, H. C., elec. engr., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Fossick, J. F., Underground engr., Memphis Light, Gas & Water Division, Memphis, Tenn.
Frolich, J. F., designing engr., Sanderson & Porter, New York.

Gentry, P. E., division plant engr., Southwestern Bell Tel. Co., Tulsa, Okla.
Glick, H. S., elec. engr., Holston Ordnance Works, Tennessee, Eastman Corp., Kingsport, Tenn.
Goldberg, Harold, senior engr., Research Dept., Stromberg-Carlson Co., Rochester, N. Y.
Hall, J. E., assistant supt. of distribution, Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
Horsfall, W. H. D., works mgr., Canada Wire & Cable Co. Ltd., Toronto, Canada.
Hughes, P. H., engr., New Jersey Bell Tel. Co., Newark, N. J.
Hunt, R. W., elec. supt., Keene District, Public Service Co. of New Hampshire, Keene, N. H.
Irey, G. W., supt. of generating stations, The Empire District Elec. Co., Joplin, Mo.
Jett, C. O., chief elec. engr., Atlas Powder Co., Paducah, Ky.
Kooker, E. M., elec. engr., General Electric Co., Cleveland, Ohio.
Lamb, F. X., Division chief, Weston Electrical Instrument Corp., Newark, N. J.
Limpel, E. J., supervisor of elec. research lab., A. O. Smith Corp., Milwaukee, Wis.
Marks, L. W., development engr., General Electric Co., Pittsfield, Mass.
Maxcy, David, assistant elec. engr., Sanderson & Porter, New York.
Menendez, R. A., elec. engr., Tampa Armature Works, Tampa, Fla.
Messinger, L. E., president, managing director, Canadian Line Materials, Ltd., Toronto, Canada.
Nordquist, C. A., district mgr., Railway & Industrial Engg. Co., Chicago, Ill.
Pickering, A. E., vice-president and general mgr., Great Lakes Power Co. Ltd., Sault Ste. Marie, Ont., Canada.
Scott, W. K., asst. elec. supt., Columbia Steel Co., Pittsburg, Calif.
Sepmeyer, L. W., associate engr., Univ. of Calif. Div. War Research, San Diego, Calif.
Thwaites, J. T., section engr., Canada Westinghouse Co., Hamilton, Canada.
Tilton, R. G., engr. and expeditor, Otis Elevator Co., New York.
Trevett, H. N., associate prof. of elec. eng., Rensselaer Polytechnic Institute, Troy, N. Y.
Van Zeeland, F. J., dean and professor of elec. engg., Milwaukee School of Engg., Milwaukee, Wis.
Veverka, Frank, Elec. engr., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Walker, W. W., general mgr., Graphite Metallizing Corp., Yonkers, N. Y.
Wold, T., chief engr., Smith & Stone, Ltd., Georgetown, Ont., Canada.

37 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. Any member objecting to the election of any of these candidates should so inform the national secretary before April 30, 1944, or June 30, 1944, if the applicant resides outside of the United States or Canada.

To Grade of Member

Balogh, S. I., Solar Mfg. Co., Bayonne, N. J.
Beatty, H. C., Southeastern Shipbuilding Corp., Savannah, Ga.
Beebe, H. D., Tampa Elec. Co., Tampa, Fla.
Bowen, J. B., San Diego Gas & Elec. Co., San Diego, Calif.
Bruns, W. H. (Re-election), Otis Elevator Co., New York, N. Y.
Charbonneau, A. P., Cutler Hammer, Inc., Milwaukee, Wis.
Coulomb, C. A., Jr., American Tel. & Tel. Co., Philadelphia, Pa.
Cronmiller, G. D., U. S. Maritime Comm., Portland, Oreg.
Crook, R. A., Alan Crook Electrical Co. Pty. Ltd., St. Leonards, Aust.
Davis, G. R., Hydro Electric Comm., Ottawa, Ont., Can.
Day, W. L. G., Lockheed Aircraft Corp., Burbank, Calif.
Dunsmoor, R. W., Webster Brinkley Co., Seattle, Wash.
Fenn, W. D., Simplex Wire & Cable Co., Cambridge, Mass.
Fox, H., General Elec. Co., Boston, Mass.
Hall, T. L., Public Service Elec. & Gas Co., Irvington, N. J.
Harc, R. J. (Re-election), Southern Calif. Tel. Co., Los Angeles, Calif.
Harrigan, M. A. P., Lieut., R.G.N.V.R., Halifax, N. S., Can.
Hassell, H. M., Demerara Elec. Co., Ltd., Georgetown, British Guiana, S. A.
Henry, E. B., Commonwealth & Southern Corp., Birmingham, Ala.
Hughes, H. D., Frick-Reid Supply Corp., Tulsa, Okla.
Johnson, E. M., General Electric Co., Seattle, Wash.
Kachni, F. J., Kaehni Bros. Laboratory, Cleveland, Ohio.
Kachni, W. L., Kaehni Bros. Laboratory, Cleveland, Ohio.
Kime, R. R. (Re-election), Sales Engineer, 40 Wall St., New York, N. Y.
Kirkpatrick, C. M. (Re-election), Westinghouse Elec. & Mfg. Co., New York, N. Y.
Langdon, G. G. (Re-election), American Gas & Elec. Service Corp., New York, N. Y.

Miller, H. P., Jr. (Re-election), Federal Tel. & Radio Corp., Newark, N. J.
 Parker, R., Electricity Commission, London, England.
 Peters, K. O., Bureau of Standards, Washington, D. C.
 Peterson, E. G. (Re-election), Cutler-Hammer, Inc., Milwaukee, Wis.
 Povey, E. H., Doble Engineering Co., Medford, Mass.
 Pullen, F. C., Tenn. Eastman Corp., Knoxville, Tenn.
 Richards, R., Electrical Contractor, Carrollton, Ga.
 Rowland, G. W., James R. Kearney Corp., St. Louis, Mo.
 Settles, O. P., Mountain States Tel. & Tel. Co., Denver, Colo.
 Skaale, A. J., Carolina Pwr. & Lt. Co., Raleigh, N. C.
 Smith, G. D., Todd Shipyards Corp., Brooklyn, N. Y.
 Tally, O. V., Allis-Chalmers Mfg. Co., St. Louis, Mo.
 Walker, F. H., Bell Aircraft Corp., Niagara Falls, N. Y.
 Whitesell, R. O., P. R. Mallory & Co., Indianapolis, Ind.
 Wolstenholme, P. G., Aluminum Co. of Can., Ltd., LaFarge, Que., Can.
 Zimmerman, D. L., Zimmerman Elec. Mchry. Co., Wichita, Kans.
 42 to grade of Member

To Grade of Associate

United States and Canada

1. NORTH EASTERN

Aguilar, J. R., General Elec. Co., Schenectady, N. Y.
 Ahrens, J. H. (Re-election), Hartford Elec. Light Co., Hartford, Conn.
 Alexander, D. C., Worcester Poly. Inst., Worcester, Mass.
 Anderson, W. T., Gen. Elec. Co., Schenectady, N. Y.
 Arana, M. O., Int. General Elec. Co., Schenectady, N. Y.
 Aude, J. R., General Elec. Co., Schenectady, N. Y.
 Baird, G. A., General Elec. Co., Schenectady, N. Y.
 Bludeau, R. E., Linde Air Products Lab., Tonawanda, N. Y.
 Brockman, M. H., Harvard Univ., Cambridge, Mass.
 Buell, L. W., Spencer Thermostat Co., Attleboro, Mass.
 Bunting, R. B., General Elec. Co., Boston, Mass.
 Bunker, J. W., General Elec. Co., Schenectady, N. Y.
 Butler, C. S., Jr., Univ. of Conn., Storrs, Conn.
 Butler, C. S., Jr., Abbott Associates, Hartford, Conn.
 Cain, D. E., General Elec. Co., Schenectady, N. Y.
 Capehart, D. F., General Elec. Co., Pittsfield, Mass.
 Champlin, F. J., USMCR, Dalton, Mass.
 Cohen, S., Mass. Inst. of Tech., Cambridge, Mass.
 Coolidge, J. E., Jr., General Elec. Co., Schenectady, N. Y.
 DeLuca, F. C., Landers, Frary & Clark, New Britain, Conn.
 Epping, F. J., Bausch & Lomb Optical Co., Rochester, N. Y.
 Escalante, G. A., General Elec. Co., Lynn, Mass.
 Franke, D. A., General Elec. Co., Schenectady, N. Y.
 Fulton, R. W., Factory Insurance Association, Syracuse, N. Y.
 Gove, I. N., Univ. of Conn., Storrs, Conn.
 Hammerstein, E. H., General Elec. Co., Schenectady, N. Y.
 Hammett, R. L., Harvard Univ., Cambridge, Mass.
 Hanna, R. L., General Elec. Co., Syracuse, N. Y.
 Harold, R. D., General Elec. Co., Schenectady, N. Y.
 Hart, M. E., General Elec. Co., Schenectady, N. Y.
 Hochseng, C. F., General Elec. Co., Schenectady, N. Y.
 Hodgers, R. W., Jr., General Elec. Co., Schenectady, N. Y.
 Hotze, I. A., General Elec. Co., Schenectady, N. Y.
 Howard, W. M., Westinghouse Elec. & Mfg. Co., South Boston, Mass.
 Hubley, F. N., Westinghouse Elec. & Mfg. Co., Boston, Mass.
 Isaacs, R. D., General Elec. Co., Schenectady, N. Y.
 Jasper, R. N., General Elec. Co., Schenectady, N. Y.
 Jensen, E. M., General Elec. Co., Schenectady, N. Y.
 Jones, A. B., Boston Edison Co., Boston, Mass.
 Kroenert, J. T., Columbia Univ. Div. of War Res., New London, Conn.
 Leigh, C. T., New Bedford Rayon Co., New Bedford, Mass.
 Loudon, J. J. M., General Elec. Co., Schenectady, N. Y.
 Loughran, J. A., General Elec. Co., Schenectady, N. Y.
 MacFec, F. O., Jr., General Elec. Co., Lynn, Mass.
 Maier, R. V., General Elec. Co., Syracuse, N. Y.
 Mather, D. L., General Elec. Co., Schenectady, N. Y.
 Mathews, C. A., General Elec. Co., Schenectady, N. Y.
 Moore, R. A., General Elec. Co., Schenectady, N. Y.
 Motter, D. P., General Electric Co., Schenectady, N. Y.
 O'Keefe, J. B., Electro Metallurgical Co., Niagara Falls, N. Y.
 Ottens, R. C., Mass. Inst. of Tech., Cambridge, Mass.
 Palmer, R. C., General Elec. Co., Schenectady, N. Y.
 Patridge, L. F., E. B. Badger & Sons Co., Boston, Mass.
 Peebles, J. E., General Elec. Co., Schenectady, N. Y.
 Perron, R. K., Sylvania Elec. Prod. Co., Inc., Salem, Mass.
 Petrich, R. O., Harvard Univ., Cambridge, Mass.
 Putnam, J. F. (Re-election), American Bosch Corp., Springfield, Mass.
 Reed, H. J., Mass. Inst. of Tech., Cambridge, Mass.
 Renner, G. W., Harvard Univ., Cambridge, Mass.
 Rescoe, J. M., Chance Vought Aircraft, Stratford, Conn.
 Roberts, E. W., Conn. Light & Power Co., Waterbury, Conn.
 Rodriguez, M. F., General Elec. Co., Schenectady, N. Y.
 Schick, R. A., General Elec. Co., Fitchburg, Mass.
 Setaro, J. E., General Elec. Co., Schenectady, N. Y.
 Sibary, T. W., General Elec. Co., Schenectady, N. Y.
 Spencer, W. B., General Elec. Co., Schenectady, N. Y.
 Stannard, G. E., Mass. Inst. Tech., Cambridge, Mass.
 Tallman, B. D., Curtis Wright Corp., Buffalo, N. Y.

TeWinkle, G. J., Niag. Lockport & Ont. Pr. Co., Medina, N. Y.
 Thomsen, J. S., General Elec. Co., Schenectady, N. Y.
 Thuma, T. E., General Elec. Co., Schenectady, N. Y.
 Thwing, S. G., General Elec. Co., West Lynn, Mass.
 Tomcik, D. J., General Elec. Co., Schenectady, N. Y.
 Tremblay, H. G., General Elec. Co., Lynn, Mass.
 Tremblay, H. G., Mass. Inst. of Tech., Cambridge, Mass.
 Tunncliffe, W. W., Mass. Inst. of Tech., Cambridge, Mass.
 Twyford, L. C., Jr., General Elec. Co., Schenectady, N. Y.
 Wahl, N. W., New York State Elec. & Gas Corp., Lockport, N. Y.
 Wheeler, D. B., General Elec. Co., Schenectady, N. Y.
 Whipple, D. C., General Elec. Co., Schenectady, N. Y.
 White, R. F., General Elec. Co., Schenectady, N. Y.
 Wholey, W. B., Harvard Univ., Cambridge, Mass.
 Williams, A. J., General Railway Signal Co., Rochester, N. Y.
 Wilson, R. D., Mass. Inst. of Tech., Boston, Mass.
 Wohlt, W. F., Jr., General Elec. Co., Pittsfield, Mass.
 Woodruff, T. E., General Elec. Co., Syracuse, N. Y.
 Vaughan, V. G., Spencer Thermostat Co., Attleboro, Mass.
 Young, R. H., General Elec. Co., Syracuse, N. Y.
 Zaskalicky, J. J., General Elec. Co., Schenectady, N. Y.

2. MIDDLE EASTERN

Allen, W. W., Jr., Naval Research Lab., Washington, D. C.
 Asbury, A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Atkinson, J. R., Naval Research Lab., Washington, D. C.
 Babcox, R. H., Jr., American Shipbuilding Co., Lorain, Ohio.
 Banks, J., U. S. Navy Yard, Philadelphia, Pa.
 Barr, H. V., Ohio Power Co., Philo, Ohio.
 Bissell, E. E., Jr., Naval Research Lab., Washington, D. C.
 Boothroyd, R. L., General Elec. Co., Erie, Pa.
 Carlstrom, T. H., Sylvania Elec. Prod., Inc., Emporium, Pa.
 Cronenberger, H. G., Alum. Co. of America, Burlington, N. J.
 DeJong, P. G., Naval Ordnance Lab., Washington, D. C.
 Deming, A. S., Jr., U. S. Navy Dept., Washington, D. C.
 Dewey, R. C., West Penn Power Co., Connellsville, Pa.
 Dobler, L. R., Naval Research Lab., Washington, D. C.
 Dominick, J. W., Phila. Elec. Co., Philadelphia, Pa.
 Duck, L. P., Philadelphia Signal Corps, Philadelphia, Pa.
 Duckwall, R. H., Frigidaire Corp., Dayton, Ohio.
 Dunn, T. E., Victor Div., Radio Corp. of Amer., Camden, N. J.
 Dykes, W. W., General Elec. Co., Philadelphia, Pa.
 Gallagher, W. M., Ohio Bell Telephone Co., Dayton, Ohio.
 Gilman, F. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Glass, W. L., General Elec. Co., Philadelphia, Pa.
 Goodman, H. A., Philco Corp., Philadelphia, Pa.
 Gruber, J. R., Naval Research Lab., Washington, D. C.
 Hageman, K. G., Naval Research Lab., Washington, D. C.
 Hagensick, C. G., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Hager, W. J., Jr., Westinghouse Elec. & Mfg. Co., Toledo, Ohio.
 Hancock, H. E., Univ. of Cincinnati, Cincinnati, Ohio.
 Hand, R. C., Reliance Elec. & Engg. Co., Cleveland, Ohio.
 Hanlon, R. P., SKF Industries, Inc., Philadelphia, Pa.
 Hawthorne, E. I., Victor Div., Radio Corp. of America, Camden, N. J.
 Hennessy, R. G., Naval Research Lab., Washington, D. C.
 Hill, V. E. (Re-election), Duquesne Light Co., Pittsburgh, Pa.
 Houston, R. H., Naval Research Lab., Washington, D. C.
 Hubbard, L. H., Jr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Kelly, R. S., Naval Research Lab., Washington, D. C.
 Knowles, R. B., Naval Ordnance Lab., Washington, D. C.
 Koenig, E., Allis-Chalmers Mfg. Co., Norwood, Ohio.
 Komer, A. J., Alum. Co. of America, Burlington, N. J.
 Kunz, C. G., Jr., Sylvania Elec. Prod., Inc., Williamsport, Pa.
 Lawrence, R. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Leedom, J. N., Naval Research Lab., Washington, D. C.
 Leslie, C. B., Naval Ordnance Lab., Washington, D. C.
 Leslie, F. A. (Re-election), Cons. Gas Elec. Lt. & Pwr. Co. of Baltimore, Baltimore, Md.
 Lindsay, E. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Livensparger, R. B., Westinghouse Elec. & Mfg. Co., Baltimore, Md.
 Locus, S. S., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Markle, L. E. (Re-election), Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Metz, W. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Michael, F. R., Univ. of Penn., Philadelphia, Pa.
 Morris, J., Princeton Univ., Princeton, N. J.
 Myers, D. K., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Myers, J. D., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Newborg, D. S., Victor Div., Radio Corp. of America, Camden, N. J.
 Oprendeck, F., Electric Serv. Supplies Co., Pittsburgh, Pa.

Oras, R., Naval Research Lab., Washington, D. C.
 Pereira, S. R., Inter-American Trade Scholarship, Washington, D. C.
 Peterson, R. E., Naval Research Lab., Washington, D. C.
 Phelan, R. F., Lear Avia, Inc., Piqua, Ohio.
 Polster, M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Rath, H. B., Mack Mfg. Corp., Allentown, Pa.
 Ray, W. C., Goodyear Tire & Rubber Co., Akron, Ohio.
 Rennie, W. A., American Shipbuilding Co., Lorain, Ohio.
 Riley, R. N., Westinghouse Elec. & Mfg. Co., Baltimore, Md.
 Robinson, J. G., Princeton Univ., Princeton, N. J.
 Rosenthal, L., Lehigh Univ., Bethlehem, Pa.
 Rydbeck, V. A., General Elec. Co., Erie, Pa.
 Schaefer, T. J., Phila. Signal Corps Procurement Dist., Philadelphia, Pa.
 Schaefer, E. J., National Defense Res. Comm., Princeton, N. J.
 Schmelzer, J. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Schmidt, D. W., Westinghouse Elec. & Mfg. Co., Lima, Ohio.
 Schultz, A. J., Sylvania Elec. Prod., Inc., Emporium, Pa.
 Shankle, D. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
 Sheffer, J. F. G., Bethlehem Steel Co., Williamsport, Pa.
 Stuart, M. J., General Elec. Co., Philadelphia, Pa.
 Thompson, D. C., Peco Products Co., Cleveland, Ohio.
 Troxel, D. L., Naval Research Lab., Washington, D. C.
 Venturine, J. B., Elliott Co., Jeannette, Pa.
 Verduin, L. C., U. S. Naval Ord. Lab., Washington, D. C.
 Watkins, J. E., Bureau of Ships, Washington, D. C.
 Webb, C. W., Naval Research Lab., Washington, D. C.
 Weber, W. H., Naval Research Lab., Washington, D. C.
 Wuerffel, H. L., Naval Research Lab., Washington, D. C.
 Yinger, L. K., Metropolitan Edison Co., York Haven, Pa.

3. NEW YORK CITY

Anderson, J. R., Bendix Aviation Corp., Bendix, N. J.
 Bachr, W. H., Arma Corp., Brooklyn, N. Y.
 Barrett, A. G., Federal Tel. & Radio Corp., New York, N. Y.
 Beebe, L. E., Curtiss-Wright Corp., Caldwell, N. J.
 Berg, A., Consolidated Diesel Electric Corp., New York, N. Y.
 Black, R. W., Conlan Elec. Corp., Brooklyn, N. Y.
 Blake, J. H., Western Elec. Co., New York, N. Y.
 Botwin, L., Bendix Avia. Corp., Brooklyn, N. Y.
 Boyd, R. H., Pennsylvania R.R. Co., New York, N. Y.
 Bradburd, E. M., Federal Tel. & Radio Labs., New York, N. Y.
 Brecht, A. J., Arma Corporation, Brooklyn, N. Y.
 Bregar, J. C., Western Elec. Co., New York, N. Y.
 Bross, R. B., Diehl Mfg. Co., Somerville, N. J.
 Buckwalter, K., U. S. Army, Ft. Monmouth, N. J.
 Burns, A. E. (Re-election), 1958 E. 29th St., Brooklyn, N. Y.
 Cataldo, J., Pierce Laboratory, Inc., Summit, N. J.
 Champion, C. E., Western Elec. Co., Inc., Kearny, N. J.
 Chardon, R. C., Puerto Rico Water Resources Auth., Guayama, P. R.
 Charlton, J., Sperry Gyroscope Co., Inc., Brooklyn, N. Y.
 Clark, M. R., U. S. Army, Ft. Monmouth, N. J.
 Clark, W. M., Sperry Products, Inc., Hoboken, N. J.
 Coe, M. R., Electricoil Transformer Co., New York, N. Y.
 Cohen, N. L., Federal Tel. & Radio Labs., New York, N. Y.
 Cox, J. W., Federal Tel. & Radio Corp., Newark, N. J.
 Danbeck, F. S., Public Serv. Elec. & Gas Co., Irvington, N. J.
 Drummond, W. F., Otis Elevator Co., Yonkers, N. Y.
 Ehrhardt, E. J., Federal Tel. & Radio Corp., Newark, N. J.
 Eubank, H. S., Poly. Inst. of Brooklyn, Brooklyn, N. Y.
 Evans, W. E., Jr., Bell Tel. Labs., New York, N. Y.
 Falk, H., Brooklyn Edison Co., Brooklyn, N. Y.
 Figueroa, J., American R.R. Co. of P. R., San Juan, P. R.
 Foster, W. P., General Cable Corp., Bayonne, N. J.
 Frey, H. B., Jr., Western Elec. Co., Kearny, N. J.
 Gilmartin, J. J., Jr., Sperry Gyroscope Co., Garden City, N. Y.
 Goethius, R. M., American Tel. & Tel. Co., New York, N. Y.
 Goodman, D. M., Standard Aircraft Prod., Inc., New York, N. Y.
 Goodman, P. D., Airborne Instrument Lab., Mineola, N. Y.
 Goronin, A., Sperry Gyroscope Co., Inc., Lake Success, N. Y.
 Grad, H., Westinghouse Elect. Elevator Co., Jersey City, N. J.
 Greenberg, J., Federal Tel. & Radio Corp., New York, N. Y.
 Gummarsall, J. R., Jefferson Travis Radio Mfg. Corp., New York, N. Y.
 Hellman, H. I., Lumms Company, New York, N. Y.
 Henches, E. N. Y. Tel. Co., New York, N. Y.
 Homa, R. E., Curtiss-Wright Corp., Caldwell, N. J.
 Huggins, C. E., Curtiss-Wright Corp., Caldwell, N. J.
 Hyman, A., Micamold Radio Corp., Brooklyn, N. Y.
 Just, G. A., Jr., Pan-American Grace Airways, New York, N. Y.
 Kalning, W. C., Induction Heating Corp., New York, N. Y.
 Kaplan, R., Electric Boat Co., Bayonne, N. J.
 King, W. J., Bell Tel. Labs., Inc., New York, N. Y.
 Koch, W. L., N. Y. Tel. Co., New York, N. Y.
 Koskos, P., Western Electric Co., New York, N. Y.
 Lacopo, M. J., American Gas & Elec. Serv. Corp., New York, N. Y.
 Lautin, M. E., Davidson Electric Co., Brooklyn, N. Y.

Livingstone, T. A., Okonite Callender Cable Co., Inc., Paterson, N. J.
 Madry, R., Allen B. DuMont Labs. Inc., Passaic, N. J.
 Malone, J. J., Curtiss-Wright Corp., Caldwell, N. J.
 Marcy, R. J., Federal Radio & Tel. Corp., Newark, N. J.
 Margosian, J. W., Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.
 McIlveen, E. E., Okonite Corp., Passaic, N. J.
 Meyer, B. C., Bell Tel. Labs., New York, N. Y.
 Miller, B. E., Sperry Gyroscope Co., Garden City, N. Y.
 Moffitt, A. B., American Tel. & Tel. Co., New York, N. Y.
 Monshaw, J. H., Penn. R.R. Co., New York, N. Y.
 Morales, D. J., Western Electric Co., New York, N. Y.
 Mulligan, J. H., Jr., Bell Tel. Labs. Inc., New York, N. Y.
 Mullin, V. E., Conlan Elec. Corp., Brooklyn, N. Y.
 Nelson, G. I., Conlan Elec. Corp., Brooklyn, N. Y.
 Ossmann, E. A., DuMont Labs. Inc., Clifton, N. J.
 Owen, R. P., Allen B. DuMont Labs. Inc., Passaic, N. J.
 Parsons, B. L., Sperry Gyroscope Co., Garden City, N. Y.
 Piller, S. E., Radio Navigational Inst. Corp., New York, N. Y.
 Plotkin, M., Bendix Aviation Corp., Brooklyn, N. Y.
 Ranks, J. E., Westinghouse Elec. & Mfg. Co., Bloomfield, N. J.
 Rigie, B., Bendix Avia. Corp., Brooklyn, N. Y.
 Rosoff, A. L., Poly. Inst. of Brooklyn, Brooklyn, N. Y.
 Rothstein, M., Federal Tel. & Radio Corp., Newark, N. J.
 Rozolis, J., Fairchild Camera & Inst. Corp., New York, N. Y.
 Sanfilippo, N., Glidden Buick Corp., New York, N. Y.
 Sauter, E. A., Teleregister Corp., New York, N. Y.
 Segall, H., Radio Receptor Co., New York, N. Y.
 Smart, T. E., Airborne Inst. Lab., Columbia Univ., Mincola, N. Y.
 Smith, H. E. (Re-election), General Electric Co., Newark, N. J.
 Stoker, F. E., U. S. Signal Corps, c/o Postmaster, New York, N. Y.
 Strauss, P. H., Victor Div. Radio Corp. of America, Harrison, N. J.
 Talesnick, S., Radio Receptor Co. Inc., New York, N. Y.
 Toppin, A. C., Fairchild Camera & Inst. Corp., New York, N. Y.
 Totah, E. J., Communication Measurements Lab., New York, N. Y.
 Turk, J., Federal Tel. & Radio Corp., New York, N. Y.
 Urbanik, J. G., W. L. Maxson Corp., New York, N. Y.
 Waas, A., Smith-Meeker Engg. Co., New York, N. Y.
 Wheye, O. M., Columbia Univ., Mincola, N. Y.

4. SOUTHERN

Adkins, B. G., Water, Gas & Electric Dept., Danville, Va.
 Becker, M. C., Tennessee Eastman Corp., Knoxville, Tenn.
 Bright, J. W., Westinghouse Elec. Sup. Co., Norfolk, Va.
 Bristol, H. C., Knoxville Power Co., Alcoa, Tenn.
 Brown, F. P., Bechtel-McCone-Parsons Corp., Birmingham, Ala.
 Campbell, J. S., Tennessee Eastman Corp., Oak Ridge, Tenn.
 Dillard, E. G., Memphis Light Gas & Water Div., Memphis, Tenn.
 Gerhart, F. A., Tennessee Eastman Corp., Oak Ridge, Tenn.
 Grantham, L. F., Andrews Steel Co., Newport, Ky.
 Harder, R. N., Alum. Co. of America, Alcoa, Tenn.
 Herring, R. L., Southern Bell Tel. Co., Atlanta, Ga.
 Holloway, C. F., Tennessee Eastman Corp., Knoxville, Tenn.
 Hudson, E. D., Tennessee Eastman Corp., Knoxville, Tenn.
 Humphrey, A. J., Alum. Co. of America, Alcoa, Tenn.
 Hunt, J. W., Shelby Electric Co., Inc., Memphis, Tenn.
 Jones, D. H., N.A.C.A., Langley Field, Va.
 Khouri, A., Univ. of Fla., Gainesville, Fla.
 Leder, W., U. S. Army, Daniel Field, Ga.
 Lees, E. M., Tennessee Eastman Corp., Oak Ridge, Tenn.
 McDonough, J. O., 2nd Lt., U. S. Army, Ft. Belvoir, Va.
 Roberson, D. A., Tennessee Eastman Corp., Oak Ridge, Tenn.
 Stevenson, J. W., Tenn. Valley Auth., Chattanooga, Tenn.
 Vanaman, L. I., Knoxville Elec. Pr. & Water Board, Knoxville, Tenn.
 Vance, F. K., Duke Univ., Durham, N. C.
 West, W. K., Alum. Co. of America, Alcoa, Tenn.
 Wise, W. R., Captain, U. S. Army, Camp McCain, Miss.

5. GREAT LAKES

Abbott, R. C., Victor Div., Radio Corp. of America, Indianapolis, Ind.
 Banky, J. B., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Burkhardt, G. N., Jr., Duncan Elec. Mfg. Co., Lafayette, Ind.
 Cooper, G. R., Purdue Univ., Lafayette, Ind.
 Crouse, C. H., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Crawford, R. S., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Currin, A. G., A. O. Smith Corp., Milwaukee, Wis.
 Dayton, G. R., General Elec. Co., Chicago, Ill.
 Douglas, L. R., Cutler-Hammer, Inc., Milwaukee, Wis.
 Drummond, B. J., General Motors Corp., Detroit, Mich.
 Fisher, G. L., A-C Spark Plug Div., Gen. Motors Corp., Flint, Mich.

Fitch, W. E., Gen. Motors Corp., Anderson, Ind.
 Fuchs, W. F., Allis-Chalmers Mfg. Co., West Allis, Wis.
 Giraud, E. J. (Re-election), Sargent & Lundy, Chicago, Ill.
 Groves, C. E., Army Air Corps, Grand Forks, N. Dak.
 Hammond, R. A. (Re-election), General Elec. Co., Milwaukee, Wis.
 Hendricks, H. E., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Hills, E. J., Highland Park Apprentice School, Highland Park, Mich.
 Huff, S. S., Commonwealth & Southern Corp., Jackson, Mich.
 Jenness, R. R., Northwestern Technological Inst., Evanston, Ill.
 Johansen, H. C. (Re-election), Purdue Univ., West Lafayette, Ind.
 Johnson, O. E., Guardian Elec. & Mfg. Co., Chicago, Ill.
 Klutts, C. A., Buick Motor Co., Flint, Mich.
 Kremmel, W. E., Cutler-Hammer, Inc., Milwaukee, Wis.
 Lawton, C. D., Allis-Chalmers Mfg. Co., West Allis, Wis.
 McCord, J. F., General Motors Corp., Anderson, Ind.
 Miller, G. W., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Mittman, E. E., Radio Corp. of America, Indianapolis, Ind.
 Mozing, A. L., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Olson, R. L., Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.
 Poenisch, C. C., Technician, 4035 Sheridan Road, Chicago, Ill.
 Potter, W. F., Potter Co., North Chicago, Ill.
 Rebecchini, P. G., Independent Pneumatic Tool Co., Aurora, Ill.
 Reeves, J. B., Cutler-Hammer, Milwaukee, Wis.
 Richardson, E. E., Public Service Co. of Ind., Indianapolis, Ind.
 Senninger, J. M., Radio & Electronic Service, Pekin, Ill.
 Templin, A. T., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Thielsch, H., Univ. of Mich., Ann Arbor, Mich.
 Underwood, O., Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.
 Votaw, E., Bendix Products Corp., South Bend, Ind.
 Wigington, L. M., Victor Div., Radio Corp. of America, Indianapolis, Ind.

6. NORTH CENTRAL

Beltran, C. R., U. S. Bureau of Reclamation, Denver, Colo.
 Musgrove, E. H., D. & R. G. W. R. R., Denver, Colo.

7. SOUTH WEST

Anderson, R. C., Wagner Electric Corp., St. Louis, Mo.
 Burwell, M. H., Kansas City Pr. & Lt. Co., Kansas City, Mo.
 Crider, N. (Re-election), Union Electric Co. of Mo., Webster Groves, Mo.
 Devlin, J. O., Jr., Combustion Engg. Co., Houston, Texas.
 Duenke, G. A. (Re-election), Moloney Electric Co., St. Louis, Mo.
 Dugas, L. V., Gulf States Util. Co., Beaumont, Texas.
 Dyer, G. L., Southwestern Bell Tel. Co., Tulsa, Okla.
 Elam, J., Univ. of Okla., Norman, Okla.
 Gemcoets, E. L., Tri-State Broadcasting Co., Inc., El Paso, Texas.
 Hope, D. L., Aircraft Accessories Corp., Kansas City, Kans.
 Lassiter, J. W., Brown Shipbuilding Co., Houston, Texas.
 Maurer, L. J., Curtiss-Wright Corp., Robertson, Mo.
 Meyer, G. C., Kansas City Pr. & Lt. Co., Kansas City, Mo.
 Pace, C. W., Brazos River Trans. Elect. Coop., Inc., Granbury, Texas.
 Schelp, D. M., Wagner Electric Co., St. Louis, Mo.
 Shaw, E. F., Magnolia Petroleum Co., Beaumont, Texas.
 Smith, C. E., Southwestern Bell Tel. Co., Tulsa, Okla.
 Walker, V. R., Alum. Co. of America, Malvern, Ark.
 Zahm, C. E., Southwestern Bell Tel. Co., Oklahoma City, Okla.

8. PACIFIC

Abramis, B. D., Consolidated Vultee Aircraft Corp., San Diego, Calif.
 Bouska, J. G., Electric Storage Battery Co., Los Angeles, Calif.
 Carson, R. M., Westinghouse Elec. & Mfg. Co., San Francisco, Calif.
 Coleman, H. L., Douglas Aircraft Co. Inc., Los Angeles, Calif.
 Dowling, R. H., Jr., U. S. Signal Office, San Francisco, Calif.
 Gardner, K. N., Southern Calif. Tel. Co., Los Angeles, Calif.
 Geraty, G. C., Jr. (Re-election), Joslyn & Ryan, San Francisco, Calif.
 Hedges, R. E., Douglas Aircraft Corp., Santa Monica, Calif.
 Jang, J., Joshua Hendy Iron Works, Sunnyvale, Calif.
 Jung, B. W., Consolidated Vultee Aircraft Corp., San Diego, Calif.
 Lodge, E. A., Arizona Power Corp., Camp Wood, Ariz.
 Matsen, M., U. S. Navy Yard, Mare Island, Calif.
 Mitchell, H. H., Kelman Elec. & Mfg. Co., Los Angeles, Calif.
 Moody, H. S., Los Angeles Shipbuilding & Drydock Corp., San Pedro, Calif.
 Muchhauser, H., U. S. Navy Yard, Mare Island, Calif.
 Newman, L., Southern Calif. Tel. Co., Los Angeles, Calif.

Overbey, C. O., Santa Fe Ry. Co., Los Angeles, Calif.
 Pattison, P. N., Jr., C. C. Moore & Co., San Francisco, Calif.
 Rader, H. E., Southern Calif. Tel. Co., Los Angeles, Calif.
 Schneider, J. R., General Electric Co., San Francisco, Calif.
 Smallman, R. L., General Elec. Co., Los Angeles, Calif.
 Sylvanus, E. C., Holmes & Narver, Los Angeles, Calif.
 Taylor, J. B., Southern Calif. Tel. Co., Los Angeles, Calif.
 Thorne, B. W., Jr., Public Service Dept., Burbank, Calif.
 Vaitses, F. A., Walsh-Kaiser, San Francisco, Calif.
 Wiley, V. G., Southern Calif. Tel. Co., Los Angeles, Calif.
 Winters, F. A., U. S. Navy Yard, Mare Island, Calif.
 Withers, J. W., Douglas Aircraft Co., El Segundo, Calif.
 Witten, E. L., Douglas Aircraft Co., Santa Monica, Calif.

9. NORTH WEST

Adams, L., Boeing Aircraft Co., Renton, Wash.
 Ammerman, D. W., Aluminum Co. of America, Spokane, Wash.
 Burton, J. H., Pan-American Airways, Seattle, Wash.
 Cook, D. W., Pan-American Airways System, Seattle, Wash.
 Dau, R., Pan-American Airways, Seattle, Wash.
 Downing, K. O., Pan-American Airways, Seattle, Wash.
 Hartsock, P. L., Alum. Co. of America, Vancouver, Wash.
 Jaccard, G. W., Jr., Boeing Aircraft Co., Seattle, Wash.
 Kampschior, D. E., Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah.
 Monroe, J. D., Boeing Aircraft Co., Renton, Wash.
 Nelthorpe, E. A., Jr., Puget Sound Pr. & Lt. Co., Seattle, Wash.
 Ralstin, R. E., Westinghouse Elec. & Mfg. Co., Spokane, Wash.
 Roberson, L. N., Dept. of Public Works, Seattle, Wash.
 Samson, R. S., Puget Sound Pwr. & Lt. Co., Bremerton, Wash.
 Stein, J. J., Puget Sound Navy Yard, Bremerton, Wash.
 Swanson, J. O., Bonneville Power Adm., Vancouver, Wash.
 Wittkopf, J. J., Oreg. State Col., Corvallis, Oreg.

10. CANADA

Fong, W. H., Montreal Light Heat & Power Co., Montreal, Que., Can.
 Hayles, O. J., Northern Elec. Co., Montreal, Que., Can.
 Humeniuk, P., Univ. of Toronto, Swansea, Ont., Can.
 Lahti, M. E., National Res. Council, Ottawa, Ont., Can.
 Marchant, C., Radio Valve Co. of Canada, Ltd., Toronto, Ont., Can.
 McCowan, W., Can. Gen. Elec. Co., Scarboro, Ont., Can.
 McKeagan, E. A., Can. Gen. Elec. Co., Montreal, Que., Can.
 Price, E. G., Northern Electric Co., Montreal, Que., Can.
 Taylor, W. M., Royal Canadian Navy, Halifax, N. S., Can.
 Vogan, B., Polymer Corp., Sarnia, Ont., Can.
 Wagner, R. N., Aluminum Co. of America, Spokane, Wash.
 Wood, J. R., Canadian Gen. Elec. Co., Peterboro, Ont., Can.

Elsewhere

Aldana, H. L., Comision Nacional Irrigacion, Mexico, D. F., Mex.
 Campistrous, V. H., Rio Negro Hydroelectric Dev., Montevideo, Urug., S. A.
 Cuenca, L. M., Street Lighting Dept., Mexico, D. F., Mex.
 Declente, G. E., National Powder Factory, Santa Fe, D. F., Mex.
 de la Torre R. M., Westinghouse Elec. Internacional, Mexico, D. F., Mex.
 Diaz, M. M. de O., Distribuidora Electrica, Mexico, D. F., Mex.
 Dultzin, S., General Supply Co., Mexico, D. F., Mex.
 Eberstadt, S. R., Industrial Hygiene Dept., Mexico, D. F., Mex.
 Flores, S. B., Cia SKF Golfo Y Caribe, S. A., Mexico, D. F., Mex.
 Fortoul, G., Mexican Lt. & Pr. Co. Ltd., Mexico, D. F., Mex.
 Gomez, V. I., Mexican Lt. & Pr. Co., Mexico, D. F., Mex.
 Graf, G. J., Electrical Contractor, Lomas de Chapultepec, Mexico, D. F., Mex.
 Hedderich, G., LaCasa Electrica de Guadalajara, S. A., Guadalajara, Jal., Mex.
 Marteny, M. L., Eago Oil & Transport Co. Ltd., Aruba, N. W. I.
 Nieto, A., Nieto & Cia., Celaya, Gto. Mex.
 Olavarrieta, F. T., Cia Distribuidora Westinghouse, Mexico, D. F., Mex.
 Orozco M. J., National Public Utilities Comm., Mexico, D. F., Mex.
 Rodriguez G. L., National Commission of Irrigation, Mexico, D. F., Mex.
 Rojas, H. C., Mexican Lt. & Pr. Co., Mexico, D. F., Mex.
 Rubio, J. M., Cia Distribuidora Westinghouse, S. A., Mexico, D. F., Mex.
 San Vicente, G., Sociedad Electromecanica, Mexico, D. F., Mex.
 Vazquez-Praderi, F., Rio-Negro Hydroelec. Dev., Montevideo, Urug., S. A.

Total to grade of Associate

United States and Canada 411

Elsewhere 22

OF CURRENT INTEREST

Underwriters' Laboratories, Inc., Reviews History of Its Development in 50 Years

Underwriters' Laboratories, Inc., non-profit organization established in 1894 by the National Board of Fire Underwriters as the official testing station of the capital-stock fire-insurance business, celebrated in February the anniversary of its first 50 years of public service. From its modest beginning above a fire-patrol station in Chicago, Ill., as a one-engineer one-room office with only \$350 worth of electrical equipment, it has developed into a national concern with four testing stations in major industrial sections of the United States. Today its central station in Chicago comprises approximately 130,000 square feet of floor area, and is said to be one of the best examples of fire-resistive construction in this country.

Underwriters' Laboratories, Inc., was an outgrowth of the first Chicago World's Fair, the Columbian Exposition of 1893. A feature of the Fair was to be a lavish display of incandescent-lamp lighting in and on the buildings. During construction of the foreground buildings a number of fires occurred, some of which were caused by the new system of lighting. Apprehensive that the new method might prove hazardous, insurance interests in Boston sent an engineer, William Henry Merrill, later the founder-president of the Laboratories, to investigate the situation.

Riding behind the horses at each call to the fairgrounds, Merrill had to determine what piece of electrical equipment, if any, had caused the fire, and why. Report number 1, covering the investigation of an electrical insulating material, was dated March 24, 1894. Since that date the Laboratories has pursued a long and close association with the electrical industry.

Merrill soon consolidated his equipment with that of William C. Robinson, chief engineer and vice-president of the new organization, who had been sent by insurance underwriters to investigate automatic sprinklers in the Chicago area. As industrial expansion began to gain momentum in the United States, the new enterprise became closely associated with it, rapidly adding to the scope of its activities until it attained its present multipurpose coverage.

In the meantime, similar investigations on behalf of insurance interests, oftentimes attaining different results, were conducted in other cities. To avoid confusion and to unify the tests, the NBFU, in 1894, gave official recognition to the Chicago testing station, and Underwriters' Laboratories, Inc., was born. Having outgrown its original and supplementary locations, the new corporation then moved into its first complete building, and in 1904 it occupied the first of the series of buildings constructed on its present site to house expanding facilities.

Fire, the original consideration, is still the principal one at the Laboratories today.

The prevention of accidents, electric shocks, explosions, burglaries, and related dangers, however, also is included in the scope of activities. Seventeen departmental laboratories equipped with much unusual and unique, as well as the standard, test equipment are represented at the main testing station in Chicago.

Because of the increasing volume of testing required by eastern manufacturers, a testing station was opened in New York, N. Y., in 1912. Work at this station is primarily in electrical, fire-alarm, and burglary-prevention fields. To serve the western part of the United States a third station, mainly for electrical work, was opened in San Francisco, Calif., in 1923. For extra hazardous work involving high explosives, toxic gases, and other dangerous products, a fourth testing station was established in the country about 35 miles out from Chicago.

"Know by Test," an admonition of its founders, is the principle underlying the Underwriters' Laboratories' activities. It was recognized early that visual inspection of the constructional features of a product and small-scale tests were not adequate to determine whether a device would operate satisfactorily or might create a hazard during normal or abnormal operation. Consequently, large-scale tests on full-size commercial products are the rule. Furnaces

for large wall sections containing full-scale fire doors or fire windows, and three-phase electric loads to match and exceed the ratings of most commercial switches are among the sizable apparatus which is standard equipment at the testing stations.

In addition to their tests, Underwriters' Laboratories has compiled about 175 published Standards, with additional tentative requirements, defining what performance and what construction is needed for safe service. Each of these Standards covers a class of products and serves as a guide both for the manufacturers and for the corporate engineers who conduct investigations.

One of the outstanding functions of the Laboratories is its inspection service. All of the products that have passed the test investigations at one of the stations are inspected periodically at the factories. A corps of technically trained men operating from 185 centers of production in the United States and Canada, in London, England, and Honolulu and Hilo, Hawaii, have made in recent years, more than 85,000 annual factory visits. These investigations involve examination of the raw materials of which the article is made, inspection of partially completed products on the production line, and tests of representative samples of the finished product selected at random.

"Underwriters' Laboratories, Inc. Inspected" labels, serially numbered, are issued by inspectors for use on products passing this factory investigation. To date 375,000 products, widely diversified, have



Figure 1. View of the electrical laboratory, Underwriters' Laboratories, Inc., in the early days. Sash weight and water-barrel variable resistor in the foreground were part of the original \$350 worth of equipment



Figure 2. A corner of the present electrical laboratory, Underwriters' Laboratories, Inc., at the main testing station in Chicago, Ill. The photograph was made at the instant of explosion of a switch during an overload test

been approved and are listed in the corporation's booklets of tested and inspected items. Four such booklets are issued annually, covering fire-protection equipment; gas, oil, and miscellaneous equipment; electrical equipment; and accident-hazard, automotive, and burglary-protection equipment.

Supplements to the first two lists are issued semi-annually, and the electrical list is brought up to date each month. In 1943, 200,000 copies were distributed free of charge to federal, state, and city authorities, industry, the armed services, inspectors, insurance people, and purchasing agents.

War and Postwar Adjustment Policies Recommended in Baruch-Hancock Report

"Victory is our first and only duty, but just as we prepare for war in time of peace, so we should prepare for peace in time of war," stated Bernard M. Baruch and John M. Hancock in transmitting their recent "Report on War and Post-War Adjustment Policies" to Director James F. Byrnes of the Office of War Mobilization. Messrs. Baruch and Hancock comprise the advisory unit for war and postwar adjustment policies of the Office of War Mobilization. In addition to the letter of transmittal and the report proper, the report booklet includes addenda giving a more extensive treatment of three subjects: contract termination, surplus property, and tightening the industrial war machine.

Declaring that "there is no need for a postwar depression, the letter of transmittal further states: "In the reconversion and readjustment will come improvements in our standards of life—better houses, better clothes better food, better safeguards for children, better health protection, and wider educational opportunities. These bring hope for the future instead of fear; they give security instead of unrest."

The specific assignment of the advisory unit was to study the immediate demobilization policies which have to do with the stimulation of war effort, since victory is the

first essential, and with the preparation for peace to follow victory. Messrs. Baruch and Hancock summarize their major suggestions as follows:

"1. Getting us all back to work in peacetime enterprises. This may require a special authority under the director of war mobilization to give its entire attention to the problem of bringing jobs to all workers, with emphasis laid upon the returning service men and service women who are our first concern.

"2. Taking the Government out of business by:

(a). Payments for work done and work under way. In connection with this phase of the problem, we have assembled a complete 'financial kit' that should prove effective. The Government must pay its debts, and pay them quickly and fully, so that business will have its working capital freed for pay rolls and purchase of materials.

(b). These payments can be made with ample protection to the Government against fraud.

(c). Move out and store war materials from plants so as to make room for equipment and materials for civilian production.

(d). Centralize the control and disposal of surpluses of all types in such a way as to bring them into ready and effective use and insure orderly markets. This, too, may require a special administrator in the Office of War Mobilization.

"3. A general tightening up of the industrial war front so as to finish the bloody business with finality, and thus be ready for peace.

"4. Spreading acceptance by war contractors of the 'Uniform Contract Article,' as recommended by us and approved by you [Director Byrnes].

"5. Place all war agencies under running review to cut them down as their work dwindles; also review of all war industrial controls.

"6. Immediate extension of laws governing price control, priorities and requisitioning, all three expiring this year.

"7. Early engineering on public works to be ready if needed to fill in the valley of unemployment.

"8. Provide credit means for those requiring it during the adjustment period, particularly for the smaller business groups and returning servicemen.

"9. Prepare now for future action reducing taxes from war to peacetime levels, thereby providing necessary incentive for initiative and enterprise and stimulating employment.

"10. Prepare an emergency 'X day' reconversion plan to be used in the event of a sudden collapse of Germany as to enable us to go on with our crusade against Japan and at the same time to prevent the dislocation resulting from lack of preparation. This phase of the broader plan is to be worked out by the armed services with the War Production Board."

Discussing the hazards of pressure groups to our postwar economy, the report deplored the widespread "loose parroting" of the slogan; "If individual enterprise fails to provide jobs for everyone, it must be replaced by some one of the other systems that are around." Pointing out that the war has been a crucible for all sorts of economic systems, the report declares that: "the American system has outproduced the world. America's productive capacity can perform still another miracle in a fine and lasting peace. It will not do so if pressure groups are permitted to turn that productive capacity into a battleground for their own selfish interests or inflate ourselves out of the world market."

Expressing their belief that a general tightening of the war machinery is necessary—both for mobilization and demobilization—Messrs. Baruch and Hancock state that "the changing conditions of the war in this respect can be pictured as dislocations that loosen the war mobilization machine and there must be a steady tightening up." Their recommendations for a general tightening of the entire Government war machine are summarized as follows:

"1. A running view of the functions of all war agencies by the Bureau of the Budget, reporting regularly to the director of war mobilization with recommendations for cutting down the agencies as their work dwindles.

"2. Intensification of the fine work already being done in sweating out unnecessary requirements in the services' programs.

"3. An early, equally effective review of the programs for raw-material production, stockpiling, imports, subsidies, and premiums to marginal producers so as not to continue any of these programs beyond being needed.

"4. Early review of all wartime materials controls and limitation measures to determine under what conditions these orders can or should be modified.

"5. Strengthening of the industry advisory committees in the War Production Board.

"6. Tightened handling and advance planning of new contracts and contract cancellation.

"7. Closer working together of the WPB and the OPA to avoid pricing delays in the resumption of civilian production.

"8. The armed services to furnish all civilian agencies full information in adequate time for these agencies to do their planning.

"9. The civilian agencies to organize themselves to use this information effectively.

"10. A running conspectus by the Office of War Mobilization of the tasks assigned each agency.

"11. No new demobilization agency needed at this time."

The report concludes with a section devoted to the "Uniform Termination Article" previously recommended by the advisory unit for war and postwar adjustment policies,

which was made effective by a directive to all procurement agencies issued by Director of War Mobilization James F. Byrnes in January. Briefly, the termination article provides that the government may terminate a prime contract at any time by giving notice. A major portion of the article consists of a statement of principles on cost determination. This cost statement is based upon the recognition only of those costs that are properly allocable to the contract and only to the extent that they are quantitatively reasonable for the performance of the whole contract.

INDUSTRY.....

Bell System Reports Extended and Improved Service in 1943

Increased radiotelephone service overseas, expansion of transcontinental telephone facilities, and limited installations of new developments offering improved quality and speed of service are some of the means by which the American Telephone and Telegraph Company has met hitherto unprecedented wartime demands, according to its annual report for 1943.

Overseas telephone service was extended during 1943 to the Union of Soviet Socialist Republics by means of a radiotelephone circuit established between New York and Moscow. Service also was inaugurated between the United States and Curacao, in the Netherlands West Indies, over a New York-Willemstad circuit, and additional facilities have been provided to Brazil, Venezuela, Central America, and Hawaii.

Since the start of the national-defense program in 1940, the number of Bell System telephones in service has increased more than 4,500,000, the daily number of conversations handled by the System has increased more than 12,000,000, and the number of long-distance conversations has increased $2\frac{1}{2}$ times. Despite the unusual difficulties, thousands of additional public telephones have been provided in and near military

establishments, with more than 400 special telephone centers staffed by operators especially trained to handle the calls for men and women in the armed services. In a few instances telephone busses or trailers housing booths and attendants have been used, pending installation of permanent facilities.

Growth of automatic or dial switching has been one of the outstanding changes in telephone service since World War I. A significant step in this growth as it affects long-distance calls was taken in 1943 when a new toll switching office at which the operator dials directly the number in the distant town or city desired by the subscriber, was installed for operation in Philadelphia. Another such development, known as "automatic ticketing," ultimately will enable subscribers in metropolitan areas to dial directly a substantial part of their calls to nearby points which now must be placed through an operator. Distinctive feature of the equipment is the automatic preparation for each call of a printed ticket showing all the information needed for charging the call to the subscriber. A form of this development has been put into commercial use in a suburban office in the Los Angeles area. A detailed reference to this development is made in the technical paper, "Automatic Ticketing of Telephone Calls," by O. A. Friend (*AIEE Trans., March '44, pp 81-8*).

Bell Telephone Laboratories, Inc., the Bell System's research organization, has engaged in over a thousand war development projects, more than half of which have been completed and many of which have found effective practical application in actual combat. These projects include all kinds of electrical communication, both wire and radio, used over land or sea and through air and water. They are not limited to communications, however; many of them involve applications of electronics to other problems of warfare.

The Western Electric Company, Inc., manufacturing branch of the System, is now engaged almost exclusively in the manufacture of materials of electronic and other war communication equipment. One of the many new war products is an electrically operated gun director, representing an entirely new principle in fire control.

Sales to the United States Government amounted to \$596,112,000 in 1943, representing 83 per cent of the total. Telephone facilities along the Alaskan military highway, and similar facilities for a line across Newfoundland, are examples of equipment the company was called upon by the Government to manufacture and install.

A number of new developments in the laboratories, either deferred by the war or resulting from war research, will be explored as soon as possible. One, of course, includes the rapid extension of coaxial cable systems, which has been postponed because of the war. These cables, which are capable of carrying several hundred telephone conversations simultaneously in two metal tubes a little larger than a lead pencil, with a copper wire in each extending along its axis, are of particular interest in connection with postwar television developments.

Leo H. Baekeland, Inventor of Bakelite Dies. Leo H. Baekeland, scientist and inventor of international repute died at Beacon, N. Y., February 23, 1944. Doctor Baekeland, who was born in Ghent, Belgium, in 1863, received the degrees of bachelor of science in 1882 and doctor of science, maxima cum laude, in 1884 from the University of Ghent. After a short time on the faculty of that university, he came to the United States on a traveling scholarship in 1889. Founding the Nepera Chemical Company in 1893 for the manufacture of photographic papers, he soon invented the printing paper known as Velox which he sold to the Eastman Kodak Company in 1899. Doctor Baekeland then established in Yonkers, N. Y., the research laboratory in which he evolved the synthetic product which he named bakelite and which became the basis of the plastic industry. In 1910 he formed the Bakelite Corporation and served as its president until his retirement in 1939. He also was associated with C. P. Townsend and E. A. Sperry in the development of the Townsend electrolytic cell. He had served on the advisory committee on chemistry of the Department of Commerce

Bell System Statistics

	Dec. 31, 1925	Dec. 31, 1930	Dec. 31, 1935	Dec. 31, 1940	Dec. 31, 1943	Increase During 1943*
Number of telephones (a).....	11,909,578.....	15,187,296.....	13,573,025.....	17,483,981.....	21,246,629.....	1,233,697
Number of central offices.....	6,147.....	6,639.....	6,896.....	7,052.....	7,311.....	107
Miles of pole lines.....	394,529.....	428,212.....	407,454.....	399,838.....	412,281.....	749
Miles of wire:						
In underground cable.....	27,769,000.....	45,116,000.....	47,639,000.....	54,339,000.....	59,321,000.....	293,000
In aerial cable.....	12,835,000.....	23,777,000.....	26,425,000.....	30,307,000.....	33,111,000.....	23,000
Open wire.....	4,339,000.....	5,231,000.....	4,562,000.....	4,660,000.....	4,938,000.....	13,000
Total.....	44,943,000.....	74,124,000.....	78,626,000.....	89,306,000.....	97,370,000.....	257,000
Average daily telephone conversations** (b).....	50,141,000.....	64,034,000.....	60,290,000.....	79,303,000.....	86,107,000.....	786,000
Total plant.....	\$ 2,566,809,000.....	\$4,028,836,000.....	\$4,187,790,000.....	\$4,747,674,000.....	\$5,387,790,000.....	\$91,132,000
Operating revenues**.....	\$ 737,560,000.....	\$1,075,228,000.....	\$ 919,116,000.....	\$1,174,322,000.....	\$1,648,077,000.....	\$178,814,000
Taxes**.....	\$ 58,113,000.....	\$ 84,732,000.....	\$ 94,507,000.....	\$ 184,770,000.....	\$ 372,936,000.....	\$ 52,383,000
Number of employees (c).....	292,902.....	318,119.....	241,169.....	275,317.....	342,980.....	15,873
Number of American Telephone and Telegraph Company stockholders.....	362,179.....	567,694.....	657,465.....	630,902.....	651,711.....	8,690

* Decreases shown in italics.

** For year ending December 31.

(a) Excludes private-line telephones numbering 100,313 on December 31, 1943, but includes telephones of about 6,200 connecting companies and more than 60,000 directly and indirectly connecting rural or farmer lines and systems. The total number of telephones in the United States which can be interconnected is approximately 26,315,000.

(b) For the year 1943 there were approximately 82,195,000 average daily local conversations and 3,912,000 toll and long-distance conversations, a decrease of 1.5 per cent and an increase of 14.2 per cent, respectively, over the year 1942.

(c) In addition, the Western Electric Company and the Bell Telephone Laboratories had 96,266 employees on December 31, 1943.

since 1925, on the United States Naval Consulting Board since 1915 and on the National Research Council. Doctor Baekeland was a member or honorary member of many French, Belgian, and British as well as American scientific societies. He had been honored with numerous medals and awards for his achievements.

Instant-Starting 40-Watt Fluorescent Lamp Now Available

Development of an instant-starting 40-watt white Mazda fluorescent lamp has been announced by General Electric Company lamp department at Nela Park, Cleveland, Ohio. It has the same rated life when operated with instant-starting ballasts as that of the present 40-watt fluorescent lamp which is started by means of the conventional switch, and by preheating.

Limited quantities of the instant-starting lamp will be made available for shipment on and after May 1 for war-production installations equipped with instant-starting ballasts, it is said.

Zenith Radionics Corporation Formed. Formation of the Zenith Radionics Corporation of New York as a subsidiary of the Zenith Radio Corporation recently was announced by J. J. Nance, vice-president and director of sales for the parent company. Establishment of the new corporation, which will be the distributor of Zenith radionics products in the area formerly covered by Colen and Gruen, New York, and E. B. Latham, New Jersey, marks a departure from the parent company's policy of independently franchised distributorships. However the parent company will adhere to its former policy except in the highly concentrated areas of New York and Chicago. H. J. Wines, formerly general sales manager of the New York and Chicago branches of the Frigidaire division of the General Motors Corporation, has been named general manager and a director of the New York corporation. E. F. McDonald, Jr., president of the Zenith Radio Corporation also heads the new corporation.

16 Groups Inaugurate National Postwar Conference

A declaration of their recognition of joint responsibility for establishing an economy of plenty and preventing mass unemployment, ruinous farm prices, and violent business cycles, came from the delegates of 16 groups representing many facets of our national economy, capital, labor, farmers, the railroads, war veterans, and fraternal organizations, meeting recently in Atlantic City, N. J., in the first session of a permanent National Postwar Conference.

Basing their belief in the need for the new organization on the theory that an effective democratic economy must be propelled by the voluntary joint action of its component groups as part of their responsibility to society, the conferees outlined the postwar objectives for which they would work as

"—an economy of plenty instead of scarcity—an opportunity for people to have jobs and increasingly better living standards and educational advantages—an opportunity for people to save and invest." The conference emphasized the fact that if the groups concerned did not "do these things together then the task will fall upon the government."

The delegates unanimously concluded "that the highest degree of prosperity and employment is assured when widespread buying power of the public, based on the production of goods and services, is maintained. It is further agreed that over any long period of time no one group can be prosperous unless the other groups are also prosperous."

Each of the organizations represented was requested to designate one member and one alternate to an organization committee to arrange for future conferences at about two-month intervals. Invitation to groups other than the original 16 also are contemplated. The future conferences will consider: agricultural problems; capital and credit; currency stabilization; distribution of products; financing social security; foreign trade; reconversion, including the problems of contract termination, renegotiation, disposition of government-owned plants, equipment and supplies, and surplus agricultural products; and taxation.

The organizations represented at the first conference were: the Aeronautical Chamber of Commerce of America, the American Bankers Association, the American Farm

Bureau Federation, the American Federation of Labor, the American Legion, the Association of American Railroads, the Chamber of Commerce of the United States, the Committee for Economic Development, the Congress of Industrial Organizations, the Investment Bankers Association of America, the Kiwanis International, the National Association of Manufacturers, the National Foreign Trade Council, the National Council of Farm Cooperatives, the National Grange, and the Rotary International.

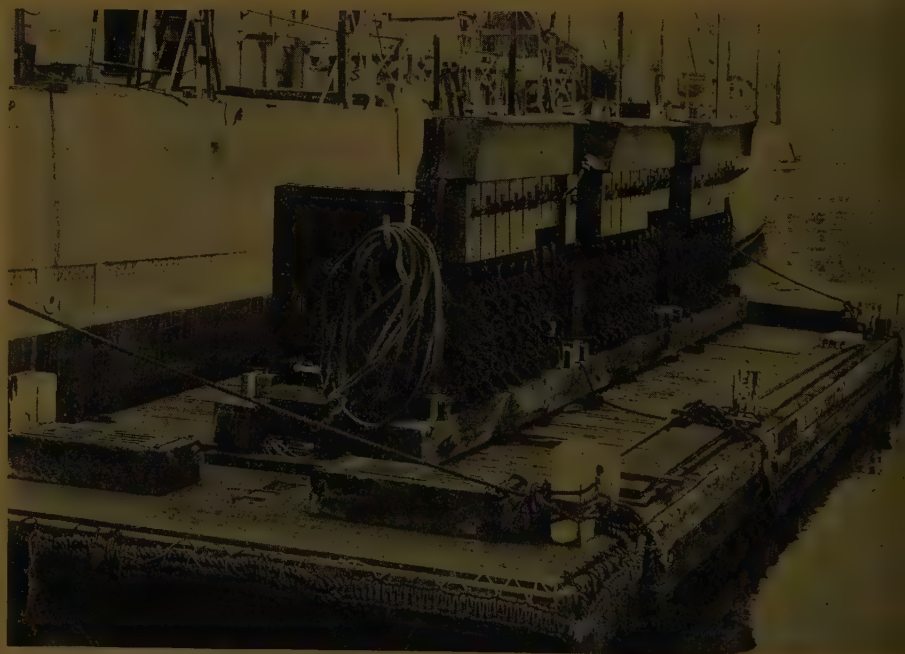
WAR PROGRAM . .

Critical Materials Still Short

The possible availability of critical materials for the manufacture of civilian goods has been a subject of much discussion recently. A recent report of the War Production Board offers a few facts for consideration.

The most critical materials used in the electrical industry have been growing scarce as the war has progressed. Barring any radical changes in the requirements of the armed forces, there seem to be adequate supplies of aluminum for essential uses. Copper and steel are fairly well balanced between supply and demand. Nickel, which is used mainly in ferroalloys, is extremely

Barges Carry Testing Equipment to New Ships



These barge-mounted immersion-type load resistors shown in the fitting-out basin of the Seattle-Tacoma Shipbuilding Corporation, Seattle, Wash., are connected by cable to the switchboard of newly launched ships to test auxiliary generating equipment. The resistors consist of banks of General Electric heaters mounted in water tanks in which the generating-equipment energy is absorbed and dissipated. Two of the barge's three tanks are for 440-volt 3-phase wye and delta connections, each connection being for 348 kw in about 6-kw steps by manual switching. The third tank is for 120 volts, single phase, and totals 9.35 kw in about 1.5-kw steps

Future Meetings of Other Societies

American Society for Testing Materials. 47th annual meeting, June 26-30, 1944, New York, N. Y.

American Society of Refrigerating Engineers. 31st spring meeting, June 5-7, 1944, Pittsburgh, Pa.

American Society of Mechanical Engineers. Semi-annual meeting, June 19-20, 1944, Pittsburgh, Pa.

Canadian Electrical Association. Annual meeting, June 22-23, 1944, Murray Bay, Que.

Edison Electric Institute. Annual conference, June 6-7, 1944, New York, N. Y.

Electrochemical Society. Spring meeting, April 12-15, 1944, Milwaukee, Wis.

Illuminating Engineering Society. Southwestern regional meeting, April 25, 1944, Dallas, Tex.; Great Lakes regional meeting, May 20, 1944, Cincinnati, Ohio.

Midwest Power Conference. April 13-14, 1944, Chicago, Ill.

National Electrical Manufacturers' Association. April 23-7, 1944, Chicago, Ill.

National Fire Protection Association. May 8-11, 1944, Philadelphia, Pa.

Pacific Coast Electrical Association. Northern section, May 10, 1944, San Francisco, Calif.; southern section, May 17, 1944, Los Angeles, Calif.

Radio Manufacturers Association. 20th annual convention, June 6-7, 1944, Chicago, Ill.

Society of Motion Picture Engineers. 55th semi-annual conference, April 17-19, 1944, New York, N. Y.

short in supply at the present, and conditions are not expected to improve, although the supply has been increased slightly in the past year.

Tin and rubber both are extremely scarce, since the war in the Pacific has blocked imports from that area. We still receive small quantities of new tin from Bolivia, but the political status there makes shipments questionable. In the meantime, we have stretched our supply by substitutions, downgrading, electrolytic plating, and salvage. We are replacing our rubber stock almost entirely with synthetic material. Zinc has been scarce for the last two years, but slab zinc is being released in freer quantities than previously. Paper and wood are both becoming less abundant, the latter having been used in many instances as a substitution for metals, but now it is just as much in demand as metallic substances.

Underwater Telephone Line Made From Spiral 4 Cable

The first underwater telephone line ever constructed from spiral 4 cable was laid in the South Pacific area from Signal Corps headquarters on Rendova Island to two divisions on the mainland under the leadership of Major George A. Reeves in July 1943, according to reports from Colonel Francis L. Ankenbrandt. Fighting was desperate in that section of the South Pacific Theater of Operations, and it was inadvisable to await the arrival of submarine telephone wire. This spiral 4 cable is often used by the Signal Corps to construct semi-permanent wire channels to the front lines, but it was not intended to withstand the pressure required for this application. To assure maximum waterproofing, it was necessary to seal the connectors of the cable with rubber and friction tapes, as they were the only materials available. Extreme care had

to be enforced in laying the cable, so as not to bruise nor sever it by the sharp coral. Anchors were made from barbed wire stakes and laid at intervals of about one eighth of a mile.

A crew of 50 men was successful in laying this cable a distance of approximately nine miles through hazardous jungles, muddy plantations, and part of the Pacific Ocean which was 1,700 feet deep at the point crossed. The party encountered heavy fire from Japanese artillery and aircraft during its progress. Two submarine circuits were linked together at Roviana Island, in the middle of the channel of water, with field wire. Time has been the deciding factor in determining the success of this experiment, and it has been proved that ordinary tape-bound spiral 4 cable, if necessary, can meet the conditions that usually necessitate a waterproof cable.

OTHER SOCIETIES.

ASA Issues Five New and Revised War Standards

Three new war standards applicable to the field of radio and two revised editions of the war standards for electric panel-type instruments and shunts have been issued recently by the American Standards Association.

The American War Standard Fixed Ceramic Dielectric Capacitors, (Temperature-Compensating Types) C75.12, available for 35 cents a copy, and the American War Standard Crystal Unit CR-1/AR, C75.11, 25 cents a copy, were prepared with the co-operation of representatives of industry and the Armed Forces at the request of the War Production Board. The American War Standard Porcelain Radio Insulators C75.14, 50 cents a copy, is the fourth and last standard in the series prepared by the IRE committee on insulation-material specifications for the military services.

The American War Standard Electrical Indicating Instruments (2 1/2- and 3 1/2-Inch, Round, Flush-Mounting, Panel-Type) C39.2, 50 cents a copy, was revised after a year's experimental use by the electrical industry and the Armed Forces, and the American War Standard External Ammeter Shunts for Panel-Type Instruments C39.5, 25 cents a copy, was revised to simplify the ranges of external ammeter shunts which are used to extend the measurement range of electric instruments.

Copies of all these standards can be obtained at the prices quoted, from the ASA, 29 West 39th St., New York 18, N. Y.

ASTM Develops Bibliography on Electrical Contacts

The American Society for Testing Materials through its committee B-4 on electrical-heating, electrical-resistance, and electric-furnace alloys has developed and published, "Bibliography on Electrical Contacts." This extensive compilation of references to the literature on electrical contacts should prove a valuable aid to those

engaged in conducting tests for evaluating different materials and types of contacts. The information provided will enable comparisons of different materials and methods of operation to be made. The abstracts included were taken chiefly from *Service Abstracts* and *Chemical Abstracts* although numerous other sources also were utilized. Because of the wide variety of problems involved in the successful functioning of contacts—microphysics of the electric arc, metallurgy of the contact materials, mechanics of the operating mechanisms, and so forth—references which have reasonable connection with those problems are included. The abstracts are listed in chronological order and for convenience there is a detailed subject and author index. The book contains 150 pages with heavy board covers, size 6 by 9 inches. Copies may be obtained at five dollars each from the ASTM, 206 South Broad Street, Philadelphia 2, Pa.

Iron and Steel Engineers Establish New Award

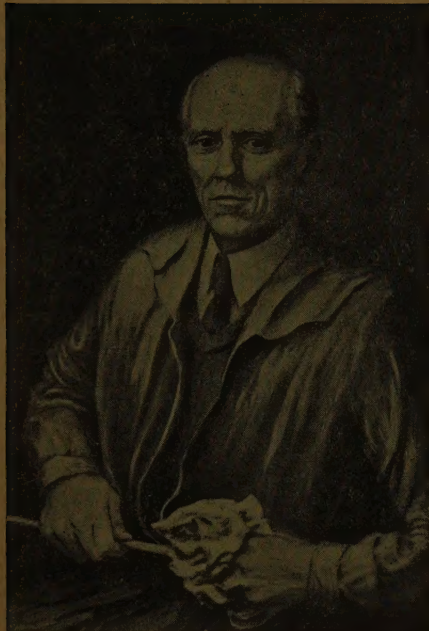
A new award has been established by the Association of Iron and Steel Engineers in commemoration of the late John F. Kelly, former managing director of the Association. This award, consisting of a certificate reciting its origin and the specific accomplishment for which it is granted, will be presented annually to that author whose paper, published by the Association, has been concluded to be of greatest value in the advancement of engineering or operating practices in the iron and steel industry. Entries for the award will be the papers published during each calendar year, although some may have been presented at meetings the previous year. Papers contributed voluntarily and not presented at meetings also will be eligible in the judging. Although it is not necessary that the author be a member of the AISE, he must be connected directly with the iron- and steel-producing industry. The award will be made by the board of directors of the Association on the recommendation of its executive committee at the annual fall meeting following the close of the calendar year.

HONORS.....

Doherty Receives Host of Honors

Robert E. Doherty (F'39) president of Carnegie Institute of Technology, Pittsburgh, Pa., was recently named Pittsburgh's "Man of the Year" by the city's Junior Chamber of Commerce, in recognition of his outstanding contributions to civic affairs. The selection, announced at the chamber's annual banquet, was only one of the many diverse honors conferred lately upon the engineering educator.

Early in February, as a tribute to his achievements and status in the fields of engineering and technical education, Doctor Doherty was made an honorary member of the Engineering Institute of Canada. A few days later he was appointed by President Roosevelt a member of the board of visitors to the



"Self Portrait" by Robert E. Doherty (F'39) awarded first prize for oil paintings at the 34th annual exhibition of the Associated Artists of Pittsburgh. It was on display at the Carnegie Institute Galleries, Pittsburgh, Pa., from February 17 to March 16, 1944

United States Naval Academy, Annapolis, Md.

Next came the announcement that a street in Schenectady, N. Y., had been named for him. It is one of four streets leading to a new municipal housing project, known as Steinmetz homes, in honor of Charles P. Steinmetz, late famed scientist of General Electric Company. Doctor Doherty was associated with Doctor Steinmetz for many years.

Recognition of his versatility in another field—this time, the arts—came with the award of first prize in the 34th exhibition of the Associated Artists of Pittsburgh for his "Self Portrait" oil painting. Painting has been his chief hobby for a number of years, but this is the first outstanding recognition he has received in this field.

Doctor Doherty has long been active in the affairs of the AIEE. In 1937 he received the AIEE Lamme Medal award "for his extension of the theory of a-c machinery, his skill in introducing that theory into practice, and his encouragement of young men to aspire to excellence in this field." He was chairman of the education committee from 1931 to 1933, and has served on the committees on electrophysics (now basic sciences), power transmission and distribution, and the technical program committee. Currently he is serving on the Edison Medal committee.

Faraday Medal Awarded to Langmuir. The Faraday Medal of the Institution of Electrical Engineers, London, England, has been awarded to Irving Langmuir, associate director of the research laboratory of the General Electric Company, Schenectady, N. Y. Doctor Langmuir is the fourth American to receive the medal which was

established in 1922 and is bestowed for world-wide services to electric science. The other American recipients of the medal were: Elihu Thomson, F. B. Jewett (F'12), and W. D. Coolidge (M'34). Doctor Langmuir, who was honored with the Nobel Prize in chemistry in 1932, has been associated with the development of modern high-vacuum tubes, and the mercury condensation pump and has engaged in studies of tungsten and thoriated tungsten filaments, the gas-filled incandescent tungsten lamp, the atomic hydrogen welding process, and oil films.

EDUCATION . . .

New Organization Formed to Assist Technical Schools

A proposed Code of Minimum Standards for Approved Technical Schools has been set up by the National Council of Technical Schools, a new organization formed in January 1944 to occupy that area of the educational field between the usual trade school and the professional engineering school.

The development of sound educational standards and ethical business practices in the technical and semiprofessional fields is one of the main objectives of the Council. Its constitution also stipulates that it be

active in the engagement of research in the advancement of educational methods, the co-operation with agencies in the promotion of adult education, and the maintenance of high standards and sound policies in educational relations with the public.

The Code of Minimum Standards contains a tentative outline of the educational, administrative, and ethical requirements member schools must possess. Requests for this pamphlet and constructive suggestions or criticisms should be sent to J. S. Noffsinger, director, The National Council of Technical Schools, 839 17th Street, Washington 6, D. C.

JOINT ACTIVITIES

Engineering Foundation Report. The Engineering Foundation, joint organization of the Founder Societies, has announced the availability in booklet form of its 1942-43 annual report. A brief summary of this report appeared in *Electrical Engineering*, January 1944 (pages 37-8). In full, it contains a financial statement; report on activities of member societies; officers, members, and committees; list of contributors; and publications. Copies may be obtained by addressing The Engineering Foundation, 29 West 39th Street, New York 18, N. Y.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly under-

stood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Mathematical Training for Young Engineers

To the Editor:

The opinions of men from industry on how much and what kind of mathematics are to be included in the undergraduate study of engineering are always of great interest to teachers of engineering, but it is quite perplexing when C. A. Powel (*EE*, Feb. '44) writes: "There should be an elective in differential equations for those students who are mathematically inclined," apparently assuming that differential equations may be of use only in postgraduate work. Whereas A. R. Stevenson, Jr., in the *Journal of Engineering Education*, May 1943, writes: "A good many undergraduate college courses include differential and integral calculus, but do not include any differential equations. Calculus is not usable on any but the most simple engineering problems unless one knows differential equations." Who is right?

The division which Mr. Powel makes as to the three levels of mathematical technology are quite interesting. In this connection it would be of interest to know how many recent graduates who had only as

much mathematics as prescribed by Mr. Powel for undergraduates are capable of reading the series of articles published last year (March to September 1943) in *Electrical Engineering* on "Ultrashort Electromagnetic Waves," or for that matter most of the articles which appear in the *Proceedings* of the Institute of Radio Engineers. And finally did Mr. Powel take into consideration the mathematical needs of students in communications when he relegated the study of Maxwell's equations to the candidates for a Doctor's degree?

J. A. STRELZOFF (A'43)

(Assistant professor of electrical engineering, Michigan State College, East Lansing)

Symbol Standardization Needed

To the Editor:

May I express my appreciation for the Number 3 AIEE *Bulletin* for the armed services just recently received.

I am now stationed at the Signal Corps Standards Agency, Red Bank, N. J. This work is much more definitely in line with engineering activities. It consists in boiling

down the number of types of components which have expanded like mushrooms in the tremendously active field of radio. In addition to reducing the number of types, we are, of course, taking every step to increase the quality and it does seem that the whole program is beginning to work out. It is the co-operation of the engineers in the electrical industry that has enabled us to accomplish what we have in this direction. In particular, vacuum tubes, meters, ceramics, capacitors, and resistors are now well in hand, and a recent meeting emphasized the need for bringing together the conflicting symbols which have plagued communications and power for years. It seems that all of this well may promote the war effort by giving better and greater quantity production with the same staff and facilities in these essential lines.

R. H. RANGER (M '22)

(Lieutenant colonel, chief, standards activities branch, Signal Corps, United States Army, Red Bank, N. J.)

Are All the Basic Problems Solved in Electrical Machinery?

To the Editor:

I have read the article, "Are All the Basic Problems Solved in Electric Machinery?" by M. M. Liwshitz in the February 1944 issue of *Electrical Engineering*, page 47. I agree with the point he has made that there is still room for development and improvement of electric machines. I also agree with his concluding statements regarding the teaching of electric machinery, and I would like to point out that this method is not new. At the University of California the method outlined has been followed for the past 14 years, and we are firmly convinced that it is the shortest and most logical one.

THOMAS C. McFARLAND (M '32)

Chairman, department of electrical engineering, University of California, Berkeley)

TVA Releases Annual Report

To the Editor:

In the February issue of *Electrical Engineering*, page 73, is printed a current news item headed, "TVA Releases Annual Report," which reads:

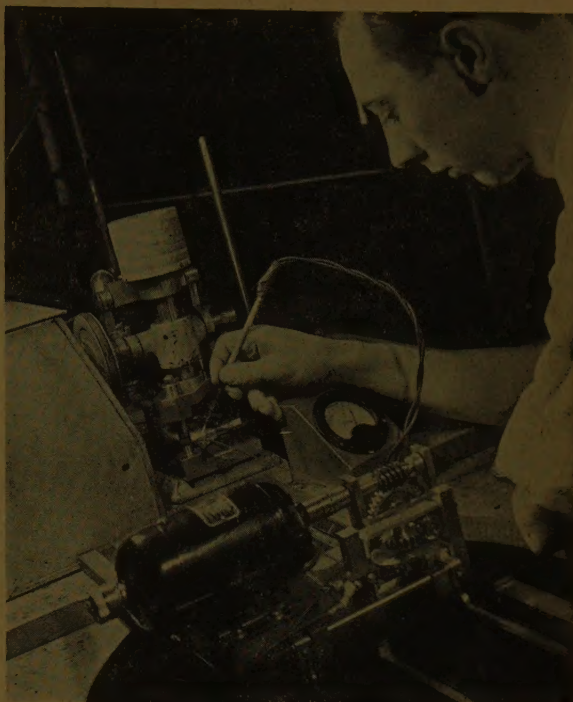
A net income of \$13,148,000 was returned to the United States Treasury from gross revenues of \$31,670,000 accruing from the sale of electric power by the Tennessee Valley Authority. . . .

In a literal sense that statement undoubtedly is true, but its import or implications are very misleading. The United States Treasury is merely a depository of TVA's funds. It would be more accurate to say that TVA deposited \$13,148,000 to its own credit in the United States Treasury. The implication of the statement is that TVA is paying some of its indebtedness to the Federal Government. That is not true as it has, so far, not paid one cent to the government in payment on its debt.

But that is not all that makes the report misleading. The taxpayers of the country paid last year at least \$20,000,000 interest on TVA's indebtedness, and they also are paying the federal taxes that TVA and its contractors should be paying to aid in the prosecution of the war.

New Machine Produces 3,500 Jewels Daily

Developed by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., after Switzerland the chief supplier of sapphires for industrial use, was blockaded by Germany, this automatic machine turns out substitute glass jewels at the rate of 3,500 per day. When the synthetic jewels first were produced it was necessary to manufacture them by hand at the rate of only 1,200 per day of which number many were imperfect. The jewels are an essential part of millions of electric instruments



For example, the private utilities of Wisconsin paid 46 cents per kilowatt hour in taxes which is more than TVA's revenue per kilowatt hour. Much of this went to the federal government in the form of income taxes, excise taxes, and capital stock taxes. The Mississippi River Power Company also sells at wholesale, but that does not exempt it from taxes. In 1942 on a gross revenue of \$6,000,000 it paid approximately \$1,500,000 in taxes to the Federal Government whereas TVA on a revenue of \$31,670,000 paid nothing.

C. M. JANSKY (F '32)

(Professor emeritus of electrical engineering, University of Wisconsin, Madison)

reactions is used freely. The function of the engineer and probable future extensions of sources and uses of power are discussed.

Electronic Physics. By L. G. Hector, H. S. Lein and C. E. Scouten. Blakiston Company, Philadelphia, Pa., 1943. 355 pages, illustrated, 8 1/2 by 5 1/2 inches, cloth, \$3.75. (ESL.)

The object of this text is to provide the beginner with a new approach to the subject. All electric phenomena are studied from the electron-proton point of view. Ordinary light, wireless, and X rays are shown to be closely related and to be various aspects of electric phenomena. Photoelectricity and electron tubes are presented as a unified part of the entire subject. Natural radioactivity and transmutation of elements are also considered in the light of the electric nature of atoms.

NEW BOOKS . . .

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Power Unleashed. By M. M. Samuels. Dorset House, Inc., New York, N. Y., 1943. 300 pages, 5 1/4 by 8 inches, \$3.50.

This descriptive story of the harnessing of the latent energy of the coal, oil, gas, and water and its transformation into safe and useful energy interprets the development and technical characteristics of electricity for the layman as well as the engineer. The ubiquity of electricity in modern life becomes apparent as the process of transporting power to the consumer is unfolded. Analogy between everyday occurrences familiar to the average layman and technical terms, structures, and

Principles and Applications of Electrochemistry, Volume 1. Principles. By H. J. Creighton. Fourth edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1943. 477 pages, illustrations, 8 1/2 by 5 1/2 inches, cloth, \$5. (ESL.)

This well-known and popular presentation of the principles and general theory of electrochemistry has been entirely revised for this edition. A number of new topics has been introduced, old material has been deleted, and new tables of data have been included. The book is intended as a text for a systematic course of instruction and as a reference book. A large number of bibliographic footnotes are included.

Aircraft Electrical Engineering. By F. G. Spreadbury. Sir Isaac Pitman and Sons, London, England; Pitman Publishing Corporation, New York, N. Y., 1943. 272

pages, illustrated, 9 by 5½ inches, cloth, \$6. (ESL.)

The various ways in which electricity is used in aircraft are presented with the needs of the designer in view. The chapters deal with ignition, ignition devices, generators and motors, uses of alternating current, voltage regulation, radio supply, ripple-smoothing circuits and ripple-voltage measurements, permanent magnets, and aircraft pyrometry.

Navigation. By L. M. Kells, W. F. Kern, and J. R. Bland. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1943. 479 pages, illustrated, 9 by 6 inches, cloth, \$5. (ESL.)

This practical textbook begins with the fundamental mathematics for pilots and descriptions of the necessary instruments and their use. Piloting methods for coastal and inland waterways are next considered, together with navigation aids and rules. The latter half of the book is devoted to the principles and practice of celestial navigation as used to determine and direct ship movements. This latter section is also basically applicable to aerial navigation.

Industrial Chemistry. By W. T. Read. Third edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1943. 631 pages, illustrated, 8½ by 5½ inches, cloth, \$5. (ESL.)

The major part of this book is devoted to authoritative information on chemical raw materials, processes and products, and on typical chemical engineering operations for many purposes. Separate chapters are included dealing with chemical organizations, sources of chemical information, chemical economics, and so forth. The purpose of this edition is to present, as far as possible, a picture of industrial chemistry as it was at the beginning of 1942.

Electric Circuits and Fields. By H. Pender and S. R. Warren. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1943. 534 pages, illustrated, 8½ by 5 inches, cloth, \$4. (ESL.)

From an engineering viewpoint this textbook gives: a description of the more important effects commonly described as electric and magnetic phenomena; a statement in words and in mathematical formulas of the fundamental laws or principles governing the relations of these phenomena; and the application of these principles to some of the simpler problems connected with the generation, transmission, and utilization of electric energy.

Aircraft Annual 1944. Edited by D. C. Cooke. First annual edition. Robert M. McBride and Company, New York 3, N. Y., 1944. 288 pages, illustrated, 9½ by 6½ inches, cloth, \$3. (ESL.)

This is the first of a series of annual reviews which will give a comprehensive account of current activities in aviation. The text is readable and nontechnical and is accompanied by a profusion of excellent illustrations. Among the topics considered are the work of the United States Army and Navy, the Doolittle Tokyo raid, the strategy of bombing, American air transport, and the manufacturing industry.

Diesel Locomotives. By J. Drancy. American Technical Society, Chicago, Ill., 1943. 472 pages, illustrated, 8½ by 5½ inches, cloth, \$4. (ESL.)

The mechanical equipment of Diesel-electric locomotives is described in detail, with specific instructions for operation and maintenance. Following the general principles of Diesel engines come several chapters on fuel injection, lubrication, governing, supercharging, and so forth. The remaining chapters deal severally with the important types of Diesel-electric locomotives currently in use. The electrical phases will be covered in a companion volume.

Geometry. By W. F. Kern and J. R. Bland. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1943. 152 pages, illustrated, 8¼ by 5 inches, cloth, \$1.75. (ESL.)

This book presents the practical essentials of solid geometry. For the development of "space intuition" a large number of exercises call for visualization of cross sections of solids in connection with reducing a problem to a number of simple problems in plane geometry. Most of the problems and illustrative examples relate to familiar objects of everyday experience or to military and naval situations.

Intermediate Course in Differential Equations. By E. D. Rainville. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1943. 213 pages, tables, 8½ by 5 inches, cloth, \$2.75. (ESL.)

This book is intended as a bridge for the gap between elementary courses and really advanced courses, and affords an introduction to several topics of importance in the classical theory. Specific topics covered include Riccati equations, the hypergeometric equation, equations of the Fuchsian type, confluence of singularities, and Whittaker's confluent hypergeometric equation.

Modern Airfield Planning and Concealment. By M. E. De Longe. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1943. 167 pages, illustrated, 9½ by 6 inches, cloth, \$4. (ESL.)

The problem of concealing airfields is discussed by a pilot with experience in camouflage. The distinctions between camouflage and concealment are pointed out, and methods, for building in maximum concealment are considered. Proper choice of airfield locations is treated. The book is intended to guide the construction of civil airfields as well as military ones.

Plastics Catalog 1944. Plastics Catalogue Corporation, 122 East 42nd Street, New York 17, N. Y., 989 pages, illustrated, 11½ by 8½ inches, cloth, \$6. (ESL.)

The 1944 edition of the catalog is a compendium of information on materials, methods of engineering, molding, fabricating, finishing and assembling, and machinery and equipment. Other sections deal with laminates, plywood, vulcanized fiber, plastic coatings, synthetic fibers, rubber, and rubberlike plastics. There is a bibliography and also a directory of sources of materials and equipment.

Synthetic Resins and Rubbers. By P. O. Powers. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1943. 296 pages, illustrated, 8½ by 5½ inches, cloth, \$3. (ESL.)

The purpose of this book is to describe briefly the chemistry of synthetic resinous materials and the raw materials from which they are made. The text is divided into the following general parts: theories of polymer formation; condensation polymers; vinyl polymers; synthetic rubbers (by K. H. Weber); resins from natural products; and application of synthetic resins.

This Fascinating Lumber Business. By S. F. Horn. Bobbs-Merrill Company, Indianapolis, Ind., and New York, N. Y., 1943. 328 pages, illustrated, 9 by 6 inches, cloth, \$3.75. (ESL.)

All phases of our lumber industry are given consideration in this informative volume. Lumbering in the West and the South, the manufacture of lumber and other forest products, methods of distribution, and the economics of the industry are discussed. Other chapters treat of warfare uses of lumber, methods of wood preservation, timber engineering, and so forth.

Maintenance Arc Welding. James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, 1943. 234 pages, illustrated, 9 by 6 inches, cloth, 50 cents in the United States; 75 cents, foreign. (ESL.)

This volume contains 25 papers which consider the uses of arc welding in maintenance work, as a means of reclaiming broken and worn equipment and fabricating replacements. Each paper discusses work in a specific plant, describing what was done, methods, and costs.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Guide to Cost Study in Corporation Postwar Planning. National Association of Manufacturers, 14 West 49th Street, New York 20, N. Y., 26 pages.

Guide to Postwar Product Development. National Association of Manufacturers, 14 West 49th Street, New York 20, N. Y., 14 pages.

Physical Fitness in Industry. Committee on Physical Fitness, Federal Security Agency, 1025 Vermont Avenue N.W., Washington 25, D. C., 15 pages.

Care and Maintenance of Electrical Equipment. Square D Company, 6060 Rivard Street, Detroit 11, Mich., 28 pages, no charge.

Preventing and Correcting Low Power Factor. George S. May Business Foundation, 111 South Dearborn Street, Chicago 3, Ill., 6 pages.

Men, Minutes, and Victory. Division of Labor Standards, United States Department of Labor, Washington 25, D. C., no charge.